ONTARIO GEOLOGICAL SURVEY

Open File Report 5590

Aggregate Resources Inventory of the Massey Area District of Sudbury

1986

Ontario

Ministry of
Northern Development
and Mines

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Aggregate Resources Inventory of the Massey Area, District of Sudbury

by

Staff of the Engineering and Terrain Geology Section,
Ontario Ministry of Northern Development and Mines

1986

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V.G. Milne

V.G. Milne, Director
Ontario Geological Survey

FOREWORD

The Massey Area, District of Sudbury, contains a number of sand and gravel deposits which were laid down during glacial times. This report and its accompanying maps delineate these deposits and provide additional information regarding their thickness, geological character and suitability for use as construction aggregate. The report also indicates which deposits possess the greatest potential for resource utilization, and discusses bedrock resource potential.

This report supplies valuable information which will be beneficial in resource planning.

V.G. Milne, Director
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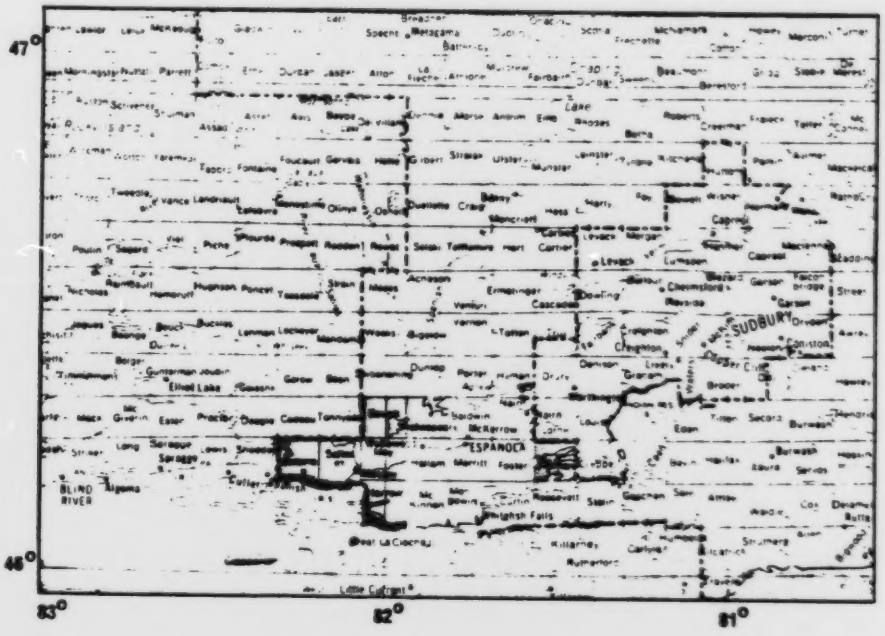

Figure 1 - Key Map Showing the Location of the Massey Area, District of Sudbury. Scale 1:1 584 000.

This report presents the results of a sand and gravel inventory in seven townships near the north shore of Lake Huron in the District of Sudbury. Eleven Resource Areas of Primary Significance have been selected for possible resource protection. These areas are considered the best suited for extractive development within the report area. The eleven Primary Resource Areas occupy a total of 1410 acres (570 ha) currently available for extraction and contain granular resources of approximately 97 million tons (88 million tonnes). In addition, several deposits

have been selected for possible resource protection at the secondary level of significance. With the exception of Truman Township, the townships in the report area contain locally significant aggregate deposits. Care should be taken to ensure the continued availability of as much of the remaining resources as possible.

An alternative source of aggregate in the study area is bedrock-derived aggregate. The bedrock consists of a complex array of metasedimentary and intrusive rocks, of which Nipissing diabase is considered the best suited for possible extractive development.

Selected Resource Areas are not intended to be permanent, single land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.

AGGREGATE RESOURCES OF THE MASSEY AREA, DISTRICT OF SUDBURY[1]

INTRODUCTION

The sand and gravel resources of Victoria, Salter, Harrow, May, Gough, Shakespeare and Truman Townships, District of Sudbury, were investigated by a two-person field party in the fall of 1985. Although the results of this work would normally be released in an Aggregate Resources Inventory Paper, the Open File Report format is used here in order to make this information available as quickly as possible. The purpose and methodology used to prepare this report are essentially the same as those used for an Aggregate Resources Inventory Paper, and are presented in Appendix A. The format in which the information is presented on the maps is explained on the map legends and in the appendices.

Granular deposits related to glacial activity are widespread in these seven townships. The Primary Resource Areas outlined later in the text include the deposits which are considered the best suited for extractive development. Because a wide range of aggregate products are capable of being produced from these deposits, the continued availability of these deposits is important. It is also important that planning strategies recognize the value of these areas in land use plans.

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[1] This project was jointly funded by Espanola District, Northeastern Region, Ontario Ministry of Natural Resources, and the Ontario Geological Survey, Ontario Ministry of Northern Development and Mines.

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This report is published with the approval of V.G. Milne, Director, Ontario Geological Survey, Ministry of Northern Development and Mines, Toronto.

LOCATION AND POPULATION

The project area consists of 7 geographic townships located near the North Shore of Lake Huron in the southwestern part of the District of Sudbury - Victoria, Salter, Harrow, May, Gough, Shakespeare, and Truman townships. Victoria, Salter, Harrow and May geographic townships have been incorporated as part of the Township of the Spanish River[2]. The Township of the Spanish River, and Gough and Shakespeare Townships lie to the west of the Town of Espanola. Truman Township lies approximately 9 miles (15 km) to the east. The report area occupies approximately 158,300 acres (64 064 ha) and is covered by the Lake Panache (41 I/3), Whitefish Falls (41 I/4), Espanola (41 I/5), Copper Cliff (41 I/6), Spanish (41 J/1) and Whiskey Lake (41 J/8) map sheets of the National Topographic System, at a scale of 1:50 000.

The population of the Township of the Spanish River was 1,591 in 1985 (Ontario Ministry of Municipal Affairs 1986). In the unorganized townships of Gough, Shakespeare, and Truman, the population is sparse. The Town of Massey is the major population centre within the report area, with a population of 1,207 in 1985 (Ontario Ministry of Municipal Affairs 1986). A smaller settlement, the community of Walford (located in Victoria Geographic Township) also serves the area. The Towns of Espanola and Elliot Lake, located outside of the project area, serve as centres for shopping, entertainment, and employment

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[2] The remaining geographic township which makes up the Township of the Spanish River is Hallam geographic township. The aggregate resources of Hallam geographic township are discussed in Open File Report 5562, Ontario Geological Survey, Ministry of Northern Affairs and Mines, 1985.

(Sables-Spanish Rivers Planning Board 1979). Economic activity in the report area is largely related to the forest industry, tourism, and farming.

Access to the area is provided by King's Highway 17 which runs east-west across May, Salter and Victoria geographic townships. Access to Truman Township is provided via King's Highway 6 which runs south through Espanola. Several gravel-surfaced roads branch off these highways. Rail service is provided by the Canadian Pacific Railway which has tracks paralleling Highways 17 and 6.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

Glacial deposits in the area are related to the last major advance and withdrawal of a continental ice sheet during the Late Wisconsinan Substage of the Pleistocene Epoch. These deposits are underlain by Precambrian bedrock, which is also exposed throughout much of the report area. The bedrock consists of a complex array of metasedimentary and intrusive rocks. The nature of these rocks has been described in detail by Card (1978), Card and Palonen (1976) and Robertson (1976). For further information on the bedrock geology of the area, the reader is referred to these reports.

The bedrock is primarily responsible for the 'rock knob' and the 'rock ridge' physiography of the report area (Gartner 1980; VanDine 1980). This topography is largely caused by differential weathering between the various rock types, as well as by erosion by the ice sheet as it moved over the area. A prominent bedrock feature in the report area are the La Cloche Mountains along the shore of Lake Huron in Harrow geographic township. These

resistant ridges of white quartzite rise between 300 and 500 feet (91 and 152 m) above the surrounding terrain.

Glacial and postglacial materials make up the remainder of the land surface. Till is the oldest surficial sediment in the report area (Boissonneau 1968). It was deposited as ice advanced to the southwest. Till is not well suited for aggregate use as it often contains excess fines and abundant oversize clasts. In places this material may be acceptable for use as fill.

Several deposits of ice-contact stratified drift were deposited in close proximity to the ice front as it melted back northward. Many of these deposits occur as small patches of sand and gravel flanking the south side of rock knobs, and contain only limited resources of aggregate. More extensive ice-contact deposits also occur within the area. A discontinuous ridge of ice-contact material, possibly of moraine origin, extends across Victoria, Salter and May geographic townships. Another significant ice-contact system, which includes an esker and a kame, is located in northwestern Harrow geographic township. Several pits have been developed in these deposits.

The outwash deposits in the study area were laid down by meltwaters flowing in bedrock depressions beyond the ice margin towards the Lake Huron basin. The most significant features are situated north of Gough Lake, south of Agnew Lake and along the River aux Sables. These deposits consist predominantly of gravelly sand, although pockets and seams of crushable gravel occur locally. These deposits have been a traditional source of aggregate in the area.

As the ice front continued to melt back, meltwaters

occupying a proglacial lake in the Lake Huron basin flooded the area. Glaciolacustrine sediments consisting of medium to fine sand, silt and clay were deposited in areas of lower elevation throughout the report area, such as the Spanish River valley in May, Salter and Victoria geographic townships, and in southern Shakespeare Township. Silt and clay were deposited in the deeper waters of the lake and in places overlies ice-contact deposits. As the lake levels lowered, shoreline wave action resulted in the development of beach deposits. Beach sand and gravel was deposited near the shore of Lake Huron along the base of prominent bedrock ridges in southern Harrow geographic township.

In the period since the disappearance of the ice sheet and the lowering of lake waters to present-day levels, erosion has been minimal. Organic deposits have developed in depressions in the land surface, and some alluvial deposits have been laid down along water courses (Gartner 1980; VanDine 1980).

EXTRACTIVE ACTIVITY

At the time of field investigation, 103 sand and gravel pits located throughout the report area were identified and plotted on Maps 1 and 2. These pits were at various stages of development. Many of the pits had been inactive for a considerable period of time, while some had been worked recently. Pit run aggregate was being extracted from several pits for local road-maintenance and construction purposes during field investigation. Many of the pits were located in small deposits and were near depletion. Other pits have been opened to supply only low-specification borrow material.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the deposits which contain granular materials. Many of these potential resource areas have limited value for reasons of size, thickness and material quality. Consequently, only the most significant sources are suggested for possible resource protection.

The selected sand and gravel resource areas are shown on Map 2. Eleven areas have been selected for possible resource protection at the primary level. The deposits contain sand and gravel deposited in ice-contact and outwash environments. Most of the report area's potential resources of crushable gravel are contained within these deposits. The eleven Primary Resource Areas occupy a total of 1410 acres (570 ha) currently available for extraction and contain granular resources of approximately 97 million tons (88 million tonnes).

Several deposits have also been selected at the secondary level of significance. These deposits are limited to a certain extent with respect to aggregate quality or the amount of available resources. However, they add significantly to the resource base of the report area and provide important alternative sources, especially for local use. Some secondary deposits may also be capable of supplying small amounts of crushable gravel.

With the exception of Truman Township, the townships in the report area appear to contain relatively abundant aggregate resources in a region in which aggregate resources are generally considered to be limited (Ontario Geological Survey 1983, 1985). Selected Sand and Gravel Resource Areas 1 and 5 consist of a series of east-west trending ice-contact deposits in Victoria,

Salter and May geographic townships. The material contained in these deposits is variable, yielding a range of aggregate products. Selected Sand and Gravel Resource Areas 2, 7 and 9 are also important aggregate sources in the report area. These outwash deposits in Salter geographic township and Gough Township contain significant amounts of crushable gravel. Selected Sand and Gravel Resource Area 10 consists of sand and gravel deposited in either an ice-contact or outwash environment. Although the remaining areas selected at the primary level are smaller ice-contact deposits, they represent important aggregate sources.

Based on field observations and on Ministry of Transportation and Communications (M.T.C.) data including petrographic examinations, the aggregate in the study area is considered hard and durable and of sufficient quality for uses including granular base coarse and 16mm crushed products. For hot-laid asphalt and concrete stone, however, petrographic numbers range from acceptable to unsuitable. The presence of argillite, greywacke and sandstone clasts of the Huronian Supergroup in some of the area's pits may limit the use of the material in structural concrete. These Huronian clasts are potentially alkali-reactive (Rodgers 1983) and testing of the aggregate is recommended prior to use in concrete products. This problem is generally restricted to the southern part of the report area. In the northern, granitic terrain, the material appears to contain relatively low percentages of Huronian clasts.

Selected Sand and Gravel resource areas are not permanent, single land use units. They represent areas in which a major

resource is believed to exist and may be reserved wholly or partially for extractive development and/or resource protection.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is located in the southern part of Victoria geographic township. It consists of four ice-contact deposits designated 1a to 1d on Map 2. The deposits contain predominantly sand, although small amounts of gravel were observed.

The pits in Area 1 exposed 5 to 40 feet (1.5 to 12 m) of predominantly sand. Zones of gravelly sand were observed in pit nos. 18 and 25. More extensive pockets of coarser gravel were noted in pit nos. 19, 22 and 24. Selective extraction procedures may be neccessary in pit no. 26 as silty seams were noted in the upper 3 to 4 feet (1 to 1.2 m), and in pit no. 24 where the aggregate is overlain by 2 to 5 feet (1 to 1.5 m) of varved clay.

The material in Area 1 generally appears suitable for pit-run uses. M.T.C. reports that the sand in Area 1b would require blending in order to be used in hot laid asphalt. Sand from pit no. 25 in Area 1d is currently being extracted to be used as mortar sand.

Resource Area 1 occupies 355 acres (144 ha), of which 186 acres (75 ha) are considered available for extraction. Assuming average deposit thicknesses of 13 feet (4 m) for Area 1a, and 20 feet (6 m) for Areas 1b, 1c and 1d, available sand and gravel resources are estimated to total 9.1 million tons (8.3 million tonnes). Access to the area is provided by King's Highway 17 which runs east-west through the southern part of Victoria

geographic township, and by several gravel-surfaced township roads which branch off the highway.

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 is located north of the Town of Massey in Salter geographic township. The deposit consists of outwash material located along the River aux Sables.

Pit no. 37 has been opened in Area 2a. Up to 30 feet (10 m) of fine to coarse sand is exposed in the pit faces. A sample contained 97 percent sand and 3 percent fines (Figure 3a). M.T.C. reports that the sand would require blending to be used in hot laid asphalt products. Sand is being actively extracted from this pit and shipped to Elliot Lake for use in concrete mix (Mrs. Crabbs, Sauble Concrete, Massey, personal communication, 1986). Fine to coarse gravel, with abundant oversize clasts, is exposed below the sand in one area of the pit. Although the deposit is suspected to consist mainly of sand, gravel similar to that exposed in the base of pit no. 37 may underlie the sand in other parts of the deposit.

There are two pits in Area 2b. Faces in pit no. 38 expose 10 to 15 feet (3 to 5 m) of coarse crushable gravel with abundant oversize material. Removal or crushing of the oversize clasts would be necessary before processing the aggregate. The depth of extraction may be restricted in places by a high water table. Five feet (1.5 m) of sand overlies the gravel in the southern part of the pit. The 8- to 10-foot (2 to 3 m) faces in pit no. 39 expose mainly sand.

Resource Area 2 occupies 300 acres (121 ha) of which 205

acres (83 ha) are considered available for extraction. Assuming an average deposit thickness of 30 feet (9 m) for Area 2a and 15 feet (5 m) for Area 2b, available sand and gravel resources are estimated to total 10.6 million tons (9.6 million tonnes). The area is readily accessible via King's Highway 553.

SELECTED SAND AND GRAVEL RESOURCE AREA 3

An esker, an ice-contact and a kame deposit, located in northwestern Harrow geographic township, have been selected at the primary level of significance. The esker (Area 3a) and kame (Area 3b) have been traditional sources of a variety of aggregate products, while the ice-contact deposit (Area 3c) is primarily a sand source.

Area 3a represents an important source of aggregate. Pit no. 49 has 20- to 25-foot (6 to 8 m) faces which reveal fine to coarse gravel. A minor clay seam was noted. Where available, the coarse material is suitable for crushing; the remaining material could be extracted for pit-run uses.

The pits developed in Area 3b have been major aggregate sources in the Massey area. Pit nos. 50 and 51 reveal 20 to 25 feet (6 to 8 m) of aggregate. Crushable gravel can be extracted from certain areas in these pits, whereas elsewhere the aggregate is suitable for pit-run uses. A sample from pit no. 50 contained 59 percent gravel, 40 percent sand, and 1 percent fines (Figure 7a).

The pits developed in Area 3c reveal 10 to 40 feet (3 to 12 m) of sand. Two feet (0.6 m) of varved clay overlies the sand in one part of pit no. 58. A six-inch (15 cm) silty seam was noted in the pit. Fine to medium gravel was observed in pit no. 59.

The material in this deposit generally appears well suited for local pit-run uses.

Approximately 119 acres (48 ha) are currently available for extraction in Resource Area 3. Assuming an average depth of 25 feet (8 m) for the deposits, aggregate resources are estimated to be 7.5 million tons (6.7 million tonnes). Access is provided by a number of gravel-surfaced roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Selected Sand and Gravel Resource Area 4 is made up of two ice-contact deposits located northeast of Chute Provincial Park in May geographic township. Although the material in the deposits is variable, they have both been classified as gravel deposits.

Area 4a represents an excellent source of aggregate. Pit nos. 68 and 69 expose 10 to 30 feet (3 to 9 m) of sand and gravel, suitable for a number of aggregate products. Gravel was being extracted and crushed from pit no. 68 during field investigation. Pit no. 67 is predominantly a sand source. In places, the aggregate in this deposit is overlain by 2 to 3 feet (0.6 to 1 m) of silt and clay. In Area 4b, pit no. 65 exposes 5 to 20 feet (1.5 to 6 m) of aggregate with variable gravel content. Approximately 3 feet (1 m) of clay overlies the flanks of the deposit.

Approximately 30 acres (12 ha) are currently available for extraction in Resource Area 4. Assuming an average depth of 20 feet (6 m) for Area 4a and 15 feet (5 m) for Area 4b, aggregate resources are estimated to be 1.4 million tons (1.3 million tonnes). Access is provided by gravel-surfaced roads branching off King's Highway 17.

SELECTED SAND AND GRAVEL AREA 5

Selected Sand and Gravel Area 5 consists of three ice-contact deposits which extend from northeast Salter geographic township into northern May geographic township. The material in these deposits is variable and parts of the deposits are covered by clay.

Test hole MY-TH-5 excavated in Area 5a exposed 2.5 feet (0.8 m) of loam over 9.5 feet (2.9 m) medium to coarse sand (Table 4). A sample of the material contained 8 percent gravel and 92 percent sand (Figure 5a). It is possible that more gravel exists within the area as coarse gravel was exposed in road cuts, occasionally overlain by clay.

Three pits in Area 5b expose a variety of material. Pit no. 70 reveals 10 to 20 feet (3 to 6 m) of medium to coarse sand with minor gravel and occasional clay and silt seams. Aggregate from this pit would be suitable for local pit-run uses. Pit no. 71 has 20- to 50-foot (6 to 15 m) faces exposing layers of clean sand and layers of coarse crushable gravel. Three to eight feet (1-2 m) of varved clay overlies the aggregate and stripping of this material would be required. It may be possible to produce crushed products from aggregate in this pit using selective extraction and sand control measures. Potential is limited, however, as bedrock is exposed in the pit face. Seismic line MY-GT-5 indicates that aggregate may extend to a significant depth north of the pit (Table 5; Map 1). Pit no. 72 reveals 30 to 40 feet (9 to 12 m) of medium to coarse gravel, suitable for crushing. A 2- to 5-foot (1 to 1.5 m) silty seam located in the face would have to be avoided during extraction.

Area 5c contains a significant potential resource of sand and gravel. The 15- to 30-foot (5 to 9 m) faces of pit no. 75 reveal zones of coarse gravel, suitable for crushing and beds of medium to coarse sand. Six feet (2 m) of varved clay overlies the aggregate in one part of the pit.

Approximately 132 acres (53 ha) are currently available for extraction in Resource Area 5. Assuming an average depth of 20 feet (6 m) for Area 5a, 30 feet (9 m) for Area 5b, and 25 feet (8 m) for Area 5c, aggregate resources are estimated to be 8.1 million tons (7.3 million tonnes). The area is readily accessible via a gravel-surfaced road which parallels the Salter-May geographic township boundary, and other gravel roads.

SELECTED SAND AND GRAVEL RESOURCE AREA 6

Selected Sand and Gravel Resource Area 6 is located on the southern shore of Gough Lake, in Gough Township, and consists predominantly of ice-contact sand with pockets of gravel. Pits no. 76 and 77 contain 5 to 15 feet (1.5 to 5 m) of clean, fine to coarse sand with minor fine gravel. Pit no. 78, which has faces 8 to 20 feet (2 to 6 m) in height, consists mainly of fine to coarse gravel. The gravel appears suitable for crushing. Selective extraction procedures would be necessary as a 6- to 8-inch (15 to 20 cm) seam of silt and clay is present.

Resource Area 6 occupies 28 acres (11 ha) of which 11 acres (4 ha) are currently considered available for extraction. Assuming an average deposit thickness of 20 feet (6 m), sand and gravel resources are estimated to total 4.6 million tons (4.2 million tonnes). Access is provided by a gravel-surfaced road.

SELECTED SAND AND GRAVEL RESOURCE AREA 7

Selected Sand and Gravel Resource Area 7 consists predominantly of outwash sand with some gravel. The deposit is located on the south shore of Gough Lake, in Gough Township. Pit no. 79 exposes 8 to 10 feet (2 to 3 m) of coarse sand and fine gravel, which appears well suited for pit-run uses. A sample contained 20 percent gravel, 78 percent sand and 2 percent fines (see Figure 8a). Seismic line MY-GT-6 indicates the possibility that aggregate extends to a significant depth in the southern part of the deposit.

Resource Area 7 occupies 21 acres (8 ha) of which 8 acres (3 ha) are currently considered available for extraction. Assuming an average deposit thickness of 10 feet (3 m), sand and gravel resources are estimated to total 0.2 million tons (0.2 million tonnes). Access to the area is provided by a gravel-surfaced road.

SELECTED SAND AND GRAVEL RESOURCE AREA 8

Selected Sand and Gravel Resource Area 8 is a hummock of ice-contact gravel in northern Gough Township. Pit no. 81 in the deposit reveals 15 to 20 feet (5 to 6 m) of aggregate. The gravel content is variable. There are beds of sand with fine gravel, suitable for use as pit run aggregate, and beds of hard, cemented sand. Pockets of coarse gravel also occur. The aggregate is overlain by 4 to 6 feet (1 to 2 m) of fines. A sample from pit no. 81 contains 52 percent gravel, 46 percent sand, and 2 percent fines (Figure 8a).

Resource Area 8 occupies 20 acres (8 ha) of which 17 acres (7 ha) are currently considered available for extraction.

Assuming an average deposit thickness of 20 feet (6 m), sand and gravel resources are estimated to be 0.9 million tons (0.8 million tonnes). The area is accessible via a gravel road.

SAND AND GRAVEL RESOURCE AREA 9

Selected Sand and Gravel Resource Area 9 is made up of two outwash deposits in northern Gough Township. Test hole MY-TH-10, in Area 9a, exposed sandy gravel over medium sand. A sample from the test hole contained 40 percent gravel, 58 percent sand and 2 percent fines (Figure 9a). It is expected that the rest of the deposit contains similar material.

Two pits, nos. 82 and 83, have been developed in Area 9b. The pits have faces ranging from 15 to 100 feet (5 to 30 m) high. Pit no. 82 contains sand and fine to medium gravel, suitable for use as pit-run aggregate, while pit no. 83 contains coarser gravel, suitable for crushing.

Resource Area 9 occupies 176 acres (71 ha) of which 147 acres (59 ha) are currently considered available for extraction. Assuming an average deposit thickness of 20 feet (6 m) for Area 9a and 60 feet (18 m) for Area 9b, sand and gravel resources are estimated to total 16.6 million tons (15.0 million tonnes). Access to the area is provided by a gravel-surfaced road.

SELECTED SAND AND GRAVEL RESOURCE AREA 10

Selected Sand and Gravel Resource Area 10 consists of three ice-contact/outwash deposits located in central Shakespeare Township. The material appears suitable for a variety of aggregate uses.

Area 10a contains large potential resources of sand and gravel. Pit no. 91 exposes 40 to 50 feet (12 to 15 m) of variable

material. Zones of sand were observed, as well as zones of coarse gravel. Some of the gravel clasts are coated with fines. Crushable products may be produced if selective extraction and sand control measures are used. In pit no. 92 the 25- to 40-foot (8 to 12 m) faces reveal sand and fine gravel suitable for pit run uses, with seams of coarse gravel. Three to five feet (1 to 1.5 m) of clay overlies the gravel. Stripping of this fine material would be necessary to avoid contamination of the underlying aggregate. Pit no. 93 contains predominantly sand with minor gravel, which is suitable for pit run uses.

Area 10b also contains significant potential resources of sand and gravel. Pit no. 89 contains 30 to 40 feet (9-12 m) of fine to coarse gravel and coarse sand. The material is generally suitable for use as pit run aggregate. Pockets of coarse gravel may be suitable for crushing if selective extraction and sand control measures are used. A sample of the aggregate contained 62 percent gravel, 37 percent sand and 1 percent fines (Figure 10a).

Pit nos. 84 to 87 have been developed in Area 10c. Faces in these pits range in height from 3 to 20 feet (1 to 6 m). The deposit consists predominantly of sand, although gravel was exposed in varying amounts in the pits. A sample from pit no. 87 contained 30 percent gravel, 67 percent sand, and 3 percent fines (Figure 10a). Although the material in this deposit appears suitable for pit run uses, zones of crushable gravel may also be present. Detailed testing would be required to determine the quantity of available crushable material.

Resource Area 10 occupies 740 acres (300 ha) of which 550 acres (223 ha) are currently considered available for extraction.

Assuming an average deposit thickness of 40 feet (12 m) for Area 10a, 35 feet (11 m) for Area 10b, and 20 feet (6 m) for Area 10c, sand and gravel resources are estimated to total 37.6 million tons (34.1 million tonnes). Access to the area is provided by a gravel road which branches off King's Highway 17.

SELECTED SAND AND GRAVEL RESOURCE AREA 11

Selected Sand and Gravel Resource Area 11 is located in southwestern Truman Township, near the shore of Lake Panache. This ice-contact gravel deposit represents a resource area of major importance, as aggregate resources in Truman Township are limited.

Pit no. 103 contains 30 to 40 percent gravel and the material is variable. The 6- to 20-foot (2 to 6 m) faces reveal pockets of crushable gravel, as well as pockets of clean sand and occasional lenses of clay. Many of the gravel clasts are weathered, and calcite coatings were observed on some of the clasts. The aggregate from this pit is suitable for pit-run uses, and may be suitable for crushing if selective extraction and sand control is used. Similar quality aggregate likely exists in the undeveloped parts of the deposit.

Resource Area 11 occupies 8 acres (3 ha), of which 7.2 acres (2.9 ha) are currently considered available for extraction. Assuming an average deposit thickness of 15 feet (5 m), sand and gravel resources are estimated to total 0.3 million tons (0.3 million tonnes). Access to the area is provided by gravel-surfaced roads.

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Nine deposits in Victoria geographic township have been selected as secondary resource areas. The deposits consist of undifferentiated ice-contact stratified drift. Although the amount of available aggregate in these areas is limited, the material remaining is considered acceptable for local use. The deposits in which pit nos. 2 and 10 are located consist predominantly of sand, but gravel was observed in the other deposits. Minor amounts of crushed stone may be available from these deposits with selective extraction of coarser gravel pockets and sand control. In pit nos. 14 and 15 the aggregate is overlain by up to 8 to 10 feet (2 to 3 m) of clay which would require stripping.

In Salter geographic township, seven sand deposits have been selected at the secondary level. Four are outwash deposits located in the northern part of the township. A sample from test hole MY-TH-2 contained 1 percent gravel, 98 percent sand, and 1 percent fines, while sample MY-TH-3 contained 13 percent gravel and 87 percent sand (Figure 4a). The sand is suitable for low-specification aggregate uses and may be suitable for asphaltic sand with blending. In the eastern part of Salter geographic township, pit no. 40 and test hole MY-TH-6 reveal medium to coarse sand, similar to the sand exposed in Selected Sand and Gravel Resource Area 2a. A sample from test hole MY-TH-6 contained 100 percent sand (Figure 6a).

Two ice-contact sand deposits are located in central Salter geographic township. One deposit is overlain by 4 to 12 feet (1 to 4 m) of silt and clay, which would require stripping. In the

other deposit, pit no. 36 and test hole MY-TH-4 expose sand suitable for pit-run uses. A sample from test hole MY-TH-4 contained 99 percent sand and 1 percent fines (Figure 5a).

One ice-contact deposit in Harrow geographic township has been selected as a secondary resource area. Both pit no. 54 and test hole MY-TH-7 revealed sand and gravel suitable for pit-run uses. Below approximately 9 feet (3 m), the gravel clasts are coated with fines which cements them together. Extraction of this cemented gravel may be difficult and therefore limits the potential of the deposit. A sample from test hole MY-TH-7 contained 63 percent gravel and 37 percent sand (Figure 7a).

Three secondary resource areas are located in May geographic township. The first, located between primary resource areas 4a and 4b, appears to have good potential as an aggregate source, but requires additional subsurface testing to confirm the type and depth of material. Localized areas may be underlain by till or rock. The other two secondary deposits are buried deposits located in northern May geographic township. Pit no. 73 exposes coarse crushable gravel, overlain by 3 to 8 feet (1 to 2 m) of clay. The potential of this deposit is limited as there are abundant oversize clasts present, and bedrock is exposed in the pit face. It is recommended that testing to determine the depth of the clay and the depth to bedrock be undertaken prior to extraction.

In Gough Township, four outwash deposits, an esker and an ice-contact deposit have been selected as secondary resource areas. The outwash deposits consist predominantly of medium

sand. Fill may be the most readily available product from these deposits. The esker and the ice-contact deposit located in the northwest corner of the township may provide coarser material.

Two outwash/ice-contact sand deposits in Shakespeare Township have been designated at the secondary level of significance. Pit no. 90 exposes fine sand which could be used for fill, while pit no. 94 contained material suitable for pit run aggregate.

An ice-contact deposit in Truman Township has been selected as a secondary resource area. The deposit contains predominantly sand. Although only small quantities of aggregate are available from this deposit, it is considered an important local source as existing aggregate resources in the area are limited.

SAND AND GRAVEL RESOURCES OF TERTIARY SIGNIFICANCE

The remaining aggregate resources in the area have been classified at the tertiary level. They represent deposits in which the material is of poor quality, or where quality information is lacking, or in which extremely limited resources are available. Many of the tertiary deposits consist of sand deposited in glaciolacustrine and outwash environments. Because the sand is often excessively fine and poorly graded, the use of these deposits is generally limited to granular borrow or fill. As well, many of the deposits classified at the tertiary level are buried under varying depths of silt and clay. This overlying material reduces their extractive potential. Despite these drawbacks, the deposits may have importance when short haul distances are of more importance than material quality.

BEDROCK RESOURCE POTENTIAL

An alternative source of aggregate within the study area is bedrock-derived aggregate. The rocks of the Precambrian Shield which underlie the area consist predominantly of Archean granitic rocks, metasedimentary rocks of the Huronian Supergroup and Nipissing diabase. These Precambrian rocks often show wide variations in mineralogy, texture (grain size) and degree of weathering, even within specific rock types and over relatively short distances. Some rock types may react slowly with cement, eventually leading to concrete deterioration. As these factors are considered important in determining the suitability of bedrock for use as aggregate, any site under consideration should be tested in detail prior to extractive development. For detailed mapping and descriptions of the rocks in the area the reader is referred to reports and mapping by Card (1978), Card and Palonen (1976) and Robertson (1976).

Of the rock types in the report area, the Nipissing diabase is considered best suited for possible extraction. As well as being a potential source of high specification aggregate, diabase can be well suited for other industrial mineral applications. Factors such as the purity of the diabase, the abrasive nature of these rocks on crushing equipment, joint pattern and market potential would influence quarry development. One quarry had been opened in the Nipissing diabase northeast of Massey (Robertson 1976). The quarry, with 10- to 20-foot (3 to 6 m) faces, was mined for trap rock, and is now inactive.

The granitic rocks may also be suited for extraction and

have been used for crushed stone elsewhere in Ontario. They may, however, react deleteriously with cement over time (Rogers, 1983). The argillites, greywackes and sandstones of the Huronian Supergroup are known to be alkali reactive and should be avoided for use in concrete in heavy duty applications.

Although there are presently no quarries actively extracting bedrock-derived aggregate in the report area, the bedrock resources may increase in importance if future demand for high specification aggregate increases. Such demand may be experienced as existing sand and gravel resources near depletion or if large construction projects are initiated in the area.

SUMMARY

Sand and gravel deposits in the report area are the product of glacial activity. Eleven Primary Resource Areas have been selected for possible resource protection. These areas are considered to have the greatest potential for extractive development and consist of aggregate ranging from sand to crushable gravel. Several deposits of secondary significance have also been selected and these areas are generally well suited for local aggregate use. Except for Truman Township where the resource base is limited, the townships in the report area contain significant aggregate deposits in an area in which aggregate resources are limited. Care should be taken to ensure the continued availability of as much of the resource areas as possible.

An alternative source of aggregate in the study area is the bedrock. The bedrock consists of a complex array of

metasedimentary and intrusive rocks, of which Nipissing diabase is considered the best suited for possible crushed stone production.

Enquiries regarding the Aggregate Resources Inventory of the Massey Area should be directed to the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Development and Mines, Room M1B-45, Macdonald Block, Queen's Park, Toronto, Ontario M7A 1W4 [Tel. (416) 965-1663], or to the Ontario Ministry of Natural Resources either at the Espanola District Office, Box 1340, 148 Fleming Street, Espanola, Ontario P0P 1C0 [Tel. (705) 869-1330] or the Northeastern Regional Office, 199 Larch Street, Sudbury, Ontario P3E 5P9 [Tel. (705) 675-4120].

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MASSEY AREA, DISTRICT OF SUDBURY

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
TOWNSHIP OF THE SPANISH RIVER			
Victoria Geographic Township			
1	G-IC	32 (13)	2 (2)
	S-IC	325 (132)	16 (15)
2	G-IC	69 (28)	2 (2)
	S-IC	86 (35)	3 (3)
3	G-IC	5 (2)	<1 (<1)
	S-IC	212 (86)	5 (4)
	S-LP	157 (64)	3 (3)
	S-OW	106 (43)	2 (2)
		990 (400)	33 (30)
Salter Geographic Township			
1	S-IC	225 (91)	13 (12)
	S-LP-OW	405 (164)	51 (46)
	S-OW	1410 (570)	123 (112)
2	G-IC	8 (3)	<1 (<1)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MASSEY AREA, DISTRICT OF SUDBURY

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-IC	57 (23)	1 (1)
	G-OW	175 (71)	7 (6)
	S-OW	420 (170)	16 (15)
3	G-IC	4 (2)	<1 (<1)
	S-IC	26 (10)	<1 (<1)
	S-IC-OW	490 (198)	10 (9)
	S-LP	1560 (630)	31 (28)
	G-OW	39 (16)	1 (1)
	S-OW	610 (245)	12 (11)
4	S-OW	152 (62)	2 (2)
		5600 (2270)	265 (240)
Harrow Geographic Township			
1	G-E	23 (9)	1 (1)
	S-IC	98 (40)	6 (5)
	G-K	51 (21)	3 (3)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MASSEY AREA, DISTRICT OF SUDBURY

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
2	G-IC	12 (5)	<1 (<1)
3	G-IC	39 (16)	1 (1)
	S-IC	15 (6)	<1 (<1)
	S-LB-LP	405 (164)	8 (7)
	S-LP	20 (8)	<1 (<1)
4	G-IC	7 (3)	<1 (<1)
	S-IC	6 (2)	<1 (<1)
		680 (275)	19 (18)
May Geographic Township			
1	G-IC	141 (57)	10 (9)
	S-IC	10 (4)	<1 (<1)
	S-LP-OW	88 (36)	11 (10)
	S-OW	17 (7)	2 (2)
2	G-E	5 (2)	<1 (<1)
	G-IC	17 (7)	1 (1)
	S-IC	58 (23)	2 (2)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MASSEY AREA, DISTRICT OF SUDBURY

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
3	G-IC	15 (6)	<1 (<1)
	S-IC	132 (53)	3 (3)
	S-LP	4200 (1700)	84 (76)
4	S-IC	5 (2)	<1 (<1)
		4700 (1900)	113 (103)
Total for the Township of the Spanish River		11,900 (4800)	430 (390)
GOUGH TOWNSHIP			
1	S-E	6 (2)	<1 (<1)
	G-IC	18 (7)	1 (1)
	S-IC	23 (9)	1 (1)
	G-OW	175 (71)	21 (19)
	S-OW	167 (68)	8 (7)
2	S-IC	57 (23)	2 (2)
	S-OW	151 (61)	5 (5)
3	S-OW	880 (355)	16 (15)
4	S-OW	32 (13)	<1 (<1)
		1510 (610)	54 (49)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MASSEY AREA, DISTRICT OF SUDBURY

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
SHAKESPEARE TOWNSHIP			
1	G-OW-IC	270 (109)	26 (24)
	S-OW-IC	760 (310)	38 (34)
2	S-IC	27 (11)	1 (1)
	S-OW-IC	89 (36)	3 (3)
3	S-LP	155 (63)	3 (3)
	S-LP-OW	365 (148)	7 (6)
	S-OW	205 (83)	4 (4)
	S-OW-IC	73 (30)	1 (1)
4	S-IC	4 (2)	<1 (<1)
	G-OW	53 (22)	<1 (<1)
		2000 (810)	83 (75)
TRUMAN TOWNSHIP			
2	G-IC	8 (3)	<1 (<1)
	S-IC	31 (12)	1 (1)
3	G-IC	7 (3)	<1 (<1)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, MASSEY AREA, DISTRICT OF SUDBURY

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
	S-LP	14 (6)	<1 (<1)
		60 (24)	1 (1)
	TOTAL FOR REPORT AREA	15,500 (6,300)	570 (520)

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
TOWNSHIP OF THE SPANISH RIVER						
Victoria Geographic Township						
1	-	NW¼	Sec 5	10-15 (3-5)	30-40	water on pit floor
2	-	NE¼	Sec 5	10-20 (3-6)	sand	
3	-	SW¼	Sec 10	15-20 (5-6)	30-40	
4	-	NE¼	Sec 18	6-8 (2)	sand	several faces; water on pit floor
5	-	NW¼	Sec 17	4-5 (1-1.5)	30-60	bedrock exposed on floor
6	-	NW¼	Sec 17	6-12 (2-4)	sand	
7	-	NW¼	Sec 15	5-20 (1.5-6)	variable	overlain by 2- to 4-foot (1 m) thick layer of clay
8	-	SE¼	Sec 15	6-20 (2-6)	sand	overlain by 4-foot (1.2 m) thick layer of clay; bedrock exposed in pit fac
9	-	NW¼	Sec 20	8-12 (2-4)	-	depleted to bedroc
10	-	NW¼	Sec 19	3-5 (1-1.5)	sand	
11	-	SE¼	Sec 19	6-20 (2-6)	50-70	
12	-	NE¼	Sec 22	10-20 (3-6)	variable	
13	-	SE¼	Sec 22	10-12 (3-4)	sand	faces slumped, over-grown

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
14	S31-44	SE¼	Sec 23	10-60 (3-18)	variable	overlain by up to 10 feet (3 m) of varved clay; near depletion
15	S31-15	SW¼	Sec 24	15-25 (5-8)	variable	overlain by up to 8 feet (2 m) of clay; near depletion
16	-	NW¼	Sec 31	10-30 (3-9)	sand	depleted to bedrock
17	S31-9	SE¼	Sec 30	10-35 (3-11)	sand	large overgrown pit
18	-	SE¼	Sec 30	6-15 (2-5)	sand	
19	-	SE¼	Sec 30	5-6 (1.5-2)	25-30	
20	-	SE¼	Sec 29	10-20 (3-6)	sand	
21	-	NE¼	Sec 29	-	-	
22	-	SW¼	Sec 28	8-15 (2-5)	mainly sand	minor gravel layers
23	S31-12	NE¼	Sec 33	10-20 (3-6)	sand	
24	-	SW¼	Sec 26	10-15 (3-5)	mainly sand	overlain by 2 to 5 feet (1-1.5 m) of clay; depleted to bedrock in one face; water on pit floor
25	S31-14	SW¼	Sec 26	30-40 (9-12)	mainly sand	worked in two levels; recent extraction
26	-	SW¼	Sec 26	10-15 (3-5)	sand	silty seams

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
Salter Geographic Township						
27	-	NW¼	Sec 10	6 (2)	sand	
28	-	NW¼	Sec 10	6-8 (2)	sand	water on pit floor overgrown
29	-	SW¼	Sec 19	12-16 (4-5)	40-50	overlain by 2- to 5-foot (1-1.5 m) thick layer of clay
30	-	NE¼	Sec 30	4-5 (1-1.5)	-	overgrown
31	-	NW¼	Sec 20	6-20 (2-6)	sand	overlain by 2-foot (1 m) thick layer of clay
32	-	SE¼	Sec 17	3-4 (1)	sand, gravel	ice-contact; up against bedrock
33	-	SE¼	Sec 17	4-8 (1-2)	sand	ice-contact; up against bedrock
34	-	SW¼	Sec 16	10-20 (3-6)	sand	
35	S31-19	NE¼	Sec 21	20-25 (6-8)	sand	overlain by 4-12 feet of of silt
36	-	NE¼	Sec 22	10-14 (3-4)	mainly sand	overlain by 1 foot (0.3 m) of silt and clay
37	S31-22 S31-21	SE¼	Sec 14	0-30 (0-10)	sand	pockets of gravel in pit floor
38	S31-33	NE¼	Sec 14	10-15 (3-5)	40-50	water on pit floor oversize
39	-	SW¼	Sec 13	8-10 (2-3)	sand	

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
40	-	NW¼	Sec 24	5-10 (1.5-3)	sand	
41	-	SW¼	Sec 24	10-15 (3-5)	mainly sand	
42	-	SW¼	Sec 25	10-15 (3-5)	sand	overgrown
43	-	NE¼	Sec 28	10-12 (3-4)	sand	depleted; bedrock exposed in floor
44	-	NE¼	Sec 28	10-12 (3-4)	sand	overgrown
45	-	SE¼	Sec 28	4 (1)	mainly sand	
46	-	SE¼	Sec 28	10-20 (3-6)		depleted, bedrock exposed in pit
47	-	SE¼	Sec 28	8-25 (2-8)	mainly sand	
Harrow Geographic Township						
48	-	12	6	10-25 (3-8)	20-30	ice-contact; overlain by 3-foot (1 m) layer of varved clay
49	-	11	5	20-25 (6-8)	30-60	recent extraction
50	-	12	5	20-25 (6-8)	20-40	recent extraction
51	-	11	5	20-25 (6-8)	30-60	recent extraction

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
52	-	7	4	8-10 (2-3)	50-70	bedrock exposed in face
53	-	7	4	10-12 (3-4)	variable	bedrock exposed in face; till pockets
54	-	4	4	5-20 (1.5-6)	30-45	gravel cemented in some parts
55	-	1	6	3-8 (1-2)	gravel	pockets of till
56	-	2	6	3-8 (1-2)	variable	abundant silt seams
57	-	9	6	15 (5)	mainly sand	
58	-	10	6	15-40 (5-12)	sand	
59	-	9	6	10-25 (3-8)	30-50	
60	-	10	6	5 (1.5)	variable	gravel flanked by lacustrine fine sands
May Geographic Township						
61	-	8	1	10-30 (3-9)	70-80	silty seams in top 3 feet (1 m); bedrock exposed in pit face
62	-	9	1	8-10 (2-3)	mainly sand	dirty gravel in top 2 feet (1 m)
63	S31-27	7	2	25-40 (8-12)	50-70	bedrock exposed in pit face; near depletion

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
64	-	11	3	-	-	overgrown
65	-	11	3	5-20 (1.5-6)	variable	slumped, overgrown
66	-	10	4	5-15 (1.5-5)	mainly sand	slumped, overgrown
67	S31-23	12	3	10-20 (3-6)	mainly sand	recent extraction
68	S31-23	12	4	10-12 (3-4)	40-60	recent extraction
69	S31-23	12	4	10-30 (3-9)	variable	recent extraction; 2 feet (1 m) of silt and clay overburden
70	-	12	5	10-20 (3-6)	10-20	
71	W19-15	11	5	20-50 (6-15)	variable	overlain by up to 8 feet (2 m) of varved clay; bedrock exposed in pit face
72	W19-15	11	5	30-40 (9-12)	50-70	silty seam in face
73	W19-27	8	5	20-50 (6-15)	25-45	overlain by 3-8 feet (1-2 m) of varved clay; bedrock exposed in pit face; oversize
74	-	7	5	-	-	
75	-	6	5	15-30 (5-9)	variable	
GOUGH TOWNSHIP						
76	-	5	1	5-15 (1.5-5)	mainly sand	

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
77	-	5	1	5-10 (1.5-3)	sand	
78	-	5	1	8-20 (2-6)	50-70	gravel pocket
79	-	4	1	8-10 (2-3)	20-30	
80	-	3	4	20 (6)	sand	
81	-	3	5	15-20 (5-6)	variable	beds of cemented sand
82	-	4	6	15-100 (5-30)	30-50	
83	-	4	6	20 (6)	variable	
SHAKESPEARE TOWNSHIP						
84	-	6	5	8-20 (2-6)	40-60	
85	-	6	5	10-18 (3-5.5)	mainly sand	
86	-	7	4	3-5 (1-1.5)	gravelly sand	presently a dump site
87	-	6	4	6-20 (2-6)	20-30	cemented
88	-	11	3	3-4 (1)	sand	bedrock exposed in face
89	E1-47	7	3	30-40 (9-12)	variable	
90	-	7	3	10-30 (3-9)	sand	
91	E1-5	6	2	40-50 (12-15)	variable	

TABLE 2 | SAND AND GRAVEL PITS, MASSEY AREA, DISTRICT OF SUDBURY

1 NO.	2 MTC NO.	3 LOT	4 CON.	5 FACE HEIGHT Feet (Metres)	6 % GRAVEL	7 REMARKS
92	E1-36-1	6	2	25-40 (8-12)	30-40	overlain by 3-5 feet (1-1.5 m) of clay
93	E1-36-2	6	2	10 (3)	mainly sand	
94	-	2	2	10-12	30-40	overlain by 2 feet (1 m) of varved clay
95	-	12	1	4-6 (1-2)	mainly sand	
96	-	9	1	8-10 (2-3)	sand	presently a dump site
97	-	7	1	10-15 (3-5)	mainly sand	slumped, overgrown
98	-	7	1	10-15 (3-5)	mainly sand	slumped, overgrown
TRUMAN TOWNSHIP						
99	-	1	4	6-10 (2-3)	mainly sand	depleted; bedrock exposed in floor
100	-	1	4	6-15 (2-5)	gravel	depleted; exposed bedrock; overgrown
101	-	10	3	15-20 (5-6)	variable	water on pit floor; bedrock exposed in pit face; abundant weathered clasts
102	-	12	1	4-5 (1-5)	gravel	
103	-	9	2	6-20 (2-6)	30-40	abundant weathered clasts

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, MASSEY AREA, DISTRICT OF SUDBURY

1	2	3	4	5	6	7
Deposit No.	AREA Acres (Hectares)	CULTURAL SETBACKS Acres (Hectares)	EXTRACTED AREA Acres (Hectares)	AVAILABLE AREA Acres (Hectares)	ESTIMATED DEPOSIT THICKNESS Feet (Metres)	AVAILABLE AGGREGATE Millions of Tons (Tonnes)
TOWNSHIP OF THE SPANISH RIVER						
Victoria Geographic Township						
1a	28 (11)	10 (4)	5 (2)	13 (5)	13 (4)	0.4 (0.4)
1b	40 (16)	12 (5)	7 (3)	21 (8)	20 (6)	1.1 (1.0)
1c	210 (85)	79 (32)	7 (3)	124 (50)	20 (6)	6.2 (5.6)
1d	75 (30)	32 (13)	15 (6)	28 (11)	20 (6)	1.4 (1.3)
	355 (144)	133 (54)	34 (14)	186 (75)		9.1 (8.3)
Salter Geographic Township						
2a	124 (50)	35 (14)	10 (4)	79 (32)	30 (9)	5.9 (5.4)
2b	175 (71)	37 (15)	12 (5)	126 (51)	15 (5)	4.7 (4.3)
	300 (121)	72 (29)	22 (9)	205 (83)		10.6 (9.6)
5a	83 (33)	17 (7)	0 (0)	66 (27)	20 (6)	3.3 (3.0)
	385 (156)	89 (36)	22 (9)	270 (110)		13.9 (12.6)
Harrow Geographic Township						
3a	23 (9)	10 (4)	2 (1)	11 (4)	25 (8)	0.7 (0.6)
3b	51 (21)	5 (2)	2 (1)	44 (18)	25 (8)	2.8 (2.5)
3c	98 (40)	32 (13)	2 (1)	64 (26)	25 (8)	4.0 (3.6)
	172 (70)	47 (19)	6 (2)	119 (48)		7.5 (6.7)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, MASSEY AREA, DISTRICT OF SUDBURY

1	2	3	4	5	6	7
Deposit No.	AREA Acres (Hectares)	CULTURAL SETBACKS Acres (Hectares)	EXTRACTED AREA Acres (Hectares)	AVAILABLE AREA Acres (Hectares)	ESTIMATED DEPOSIT THICKNESS Feet (Metres)	AVAILABLE AGGREGATE Millions of Tons (Tonnes)
May Geographic Township						
4a	20 (8)	0 (0)	5 (2)	15 (6)	20 (6)	0.8 (0.7)
4b	22 (9)	5 (2)	2 (1)	15 (6)	15 (5)	0.6 (0.5)
	42 (7)	5 (2)	7 (3)	30 (12)		1.4 (1.3)
5a	2 (1)	0 (0)	0 (0)	2 (1)	20 (6)	0.1 (0.1)
5b	80 (32)	15 (6)	10 (4)	55 (22)	30 (9)	4.1 (3.7)
5c	11 (4)	0 (0)	2 (1)	9 (4)	25 (8)	0.6 (0.5)
	93 (38)	15 (6)	12 (5)	66 (27)		4.8 (4.4)
6	2 (1)	0 (0)	0 (0)	2 (1)	20 (6)	0.1 (0.1)
	137 (55)	20 (8)	19 (8)	98 (40)		6.3 (5.7)
Total for the Township of the Spanish River	1050 (425)	290 (117)	81 (33)	670 (270)		36.8 (33.4)
GOUGH TOWNSHIP						
6	26 (10)	15 (6)	2 (1)	9 (4)	20 (6)	4.5 (4.1)
7	21 (8)	12 (5)	1 (0.4)	8 (3)	10 (3)	0.2 (0.2)
8	20 (8)	0 (0)	1 (0.4)	17 (7)	20 (6)	0.9 (0.8)
9a	55 (22)	0 (0)	0 (0)	55 (22)	20 (6)	2.8 (2.5)
9b	121 (49)	27 (11)	2 (1)	92 (37)	60 (18)	13.8 (12.5)
	176 (71)	27 (11)	2 (1)	147 (59)		16.6 (15.0)
	243 (98)	54 (22)	6 (2)	181 (73)		22.2 (20.1)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, MASSEY AREA, DISTRICT OF SUDBURY

1	2	3	4	5	6	7
Deposit No.	AREA Acres (Hectares)	CULTURAL SETBACKS Acres (Hectares)	EXTRACTED AREA Acres (Hectares)	AVAILABLE AREA Acres (Hectares)	ESTIMATED DEPOSIT THICKNESS Feet (Metres)	AVAILABLE AGGREGATE Millions of Tons (Tonnes)
SHAKESPEARE TOWNSHIP						
10a	167 (68)	27 (11)	2 (1)	138 (56)	40 (12)	13.8 (12.5)
10b	105 (42)	17 (7)	5 (2)	83 (34)	35 (11)	7.3 (6.6)
10c	470 (190)	138 (56)	2 (1)	330 (134)	20 (6)	16.5 (15.0)
	740 (300)	182 (74)	9 (4)	550 (223)		37.6 (34.1)
TRUMAN TOWNSHIP						
11	8 (3)	0 (0)	0.6 (0.2)	7.2 (2.9)	15 (5)	0.3 (0.3)
TOTAL FOR REPORT AREA	2040 (830)	530 (214)	96.6 (39.1)	1410 (570)		97 (88)

TABLE 4 - SUMMARY OF TEST HOLE DATA, MASSEY AREA

TOWNSHIP OF THE SPANISH RIVER

Test Hole Number: MY-TH-1

Location: Victoria Geographic Township, Section 21, NW¼

Elevation: Approximately 900 feet (274 m) a.s.l.

Date: October 9, 1985

Depth feet (metres)	Description
0-6.0 (0-1.8)	clean, medium sand
6.0-8.0 (1.8-2.4)	reworked silty sand till with trace fine gravel
8.0-13.0 (2.4-4.0)	compact silty sand till with occasional clay till zones

Test Hole Number: MY-TH-2

Location: Salter Geographic Township, Section 6, NE ¼

Elevation: Approximately 875 feet (267 m) a.s.l.

Date: October 9, 1985

Depth feet (metres)	Description
0-3.0 (0-0.9)	medium sand with some coarse sand and trace fine gravel
3.0-3.5 (0.9-1.1)	horizontally stratified and ripple laminated fine sand
3.5-4.5 (1.1-1.4)	medium sand
4.5-10.0 (1.4-3.0)	medium sand with some coarse sand and little fine gravel
10.0-12.0 (3.0-3.7)	little fine to medium sand

TABLE 4 - SUMMARY OF TEST HOLE DATA, MASSEY AREA

Test Hole Number: MY-TH-3

Location: Salter Geographic Township, Section 4, NW ¼

Elevation: Approximately 850 feet (259 m) a.s.l.

Date: October 9, 1985

Depth feet (metres)	Description
0-3.5 (0-1.1)	medium to coarse sand with trace fine gravel
3.5-4.5 (1.1-1.4)	medium to coarse sand
4.5-6.5 (1.4-2.0)	coarse sand with some fine gravel
6.5-10.0 (2.0-3.0)	medium sand with some coarse sand
10.0-14.0 (3.0-4.3)	silt

Test Hole Number: MY-TH-4

Location: Salter Geographic Township, Section 22, NE ¼

Elevation: Approximately 750 feet (229 m) a.s.l.

Date: October 9, 1985

Depth feet (metres)	Description
0-1.5 (0-0.5)	sandy loam
1.5-5.0 (0.5-1.5)	medium sand
5.0-9.0 (1.5-2.7)	coarse sand with trace fine gravel
9.0-15.0 (2.7-4.6)	coarse sand with little fine to medium gravel

TABLE 4 - SUMMARY OF TEST HOLE DATA, MASSEY AREA

Test Hole Number: MY-TH-5

Location: Salter Geographic Township, Section 13, NW ¼

Elevation: Approximately 825 feet (251 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	Description
0-2.5 (0-0.8)	loam
2.5-12.0 (0.8-3.7)	medium to coarse sand with little fine gravel, bedding inclined to south

Test Hole Number: MY-TH-6

Location: Salter Geographic Township, Section 13, NW ¼

Elevation: Approximately 775 feet (236 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	Description
0-2.0 (0-0.6)	oxidised medium sand
2.0-12.0 (0.6-3.7)	medium sand with some coarse sand

TABLE 4 - SUMMARY OF TEST HOLE DATA, MASSEY AREA

Test Hole Number: MY-TH-7

Location: Harrow Geographic Township, Lot 4, Conc. IV

Elevation: Approximately 725 feet (221 m) a.s.l.

Date: October 9, 1985

Depth feet (metres)	Description
0-1.0 (0-0.3)	silt
1.0-2.5 (0.3-0.8)	angular, open-worked medium to coarse gravel
2.5-5.5 (0.8-1.7)	fine gravel with some coatings of fines
5.5-6.0 (1.7-1.8)	silty very fine sand
6.0-8.0 (1.8-2.4)	compact medium sand
8.0-9.0 (2.4-2.7)	gravel with some silty very fine sand
9.0-13.0 (2.7-4.0)	fine to coarse gravel with clasts coated with fines, cemented

Test Hole Number: MY-TH-8

Location: Lot 6, Conc. VI, May Geographic Township

Elevation: Approximately 800 feet (244 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	Description
0-12.0 (0-3.7)	silt and clay grading downwards into silty fine sand

TABLE 4 - SUMMARY OF TEST HOLE DATA, MASSEY AREA

GOUGH TOWNSHIP

Test Hole Number: MY-TH-9

Location: Gough Township, Lot 2, Conc. V

Elevation: Approximately 900 feet (274 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	Description
0-8.0 (0-2.4)	medium sand

Test Hole Number: MY-TH-10

Location: Gough Township, Lot 3, Conc. V

Elevation: Approximately 950 feet (290 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	Description
0-4 (0-1.2)	sandy gravel
4.0-14.0 (1.2-4.3)	medium sand with trace coarse sand

SHAKESPEARE TOWNSHIP

Test Hole Number: MY-TH-11

Location: Shakespeare Township, Lot 7, Conc. V

Elevation: Approximately 1000 feet (305 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	Description
0-2.0 (0-0.6)	clayey loam
2.0-8.0 (0.6-2.4)	clayey silty sand till

TABLE 4 - SUMMARY OF TEST HOLE DATA, MASSEY AREA

Test Hole Number: MY-TH-12

Location: Shakespeare Township, Lot 7, Conc. III

Elevation: Approximately 1025 feet (312 m) a.s.l.

Date: October 10, 1985

Depth feet (metres)	**Description**
0-2.0 (0-0.6)	sandy fine to coarse gravel over rock

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, MASSEY AREA

TOWNSHIP OF THE SPANISH RIVER

Line Number: MY-GT-1

Line Direction: N 60° E

Method: Hammer Seismic

Location: Salter Geographic Township, Section 6, NE ¼

Elevation: Approximately 850 feet (259 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1500 ft/sec (455 m/sec)
V_2= 1930 ft/sec (590 m/sec)
Layer Thickness: D_1= 5 ft (1.5 m)

Interpretation: Approximately 5 feet (1.5 m) of loose dry sand over denser sand and gravel to a minimum of 40 feet (12.2 m).

Line Number: MY-GT-2

Line Direction: North-South

Method: Hammer Seismic

Location: Salter Geographic Township, Section 4, NW ¼

Elevation: Approximately 900 feet (274 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1140 ft/sec (350 m/sec)
V_2= 4000 ft/sec (1220 m/sec)
Layer Thickness: 18 ft (5.5 m)

Interpretation: Approximately 18 feet (5.5 m) of dry sand over wet sand and gravel to a minimum of 40 feet (12.2 m).

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, MASSEY AREA

Line Number: MY-GT-3

Line Direction: S 20° E

Method: Hammer Seismic

Location: Salter Geographic Township, Section 13, SE ¼

Elevation: Approximately 750 feet (229 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1120 ft/sec (340 m/sec)
V_2= 1620 ft/sec (495 m/sec)
Layer Thickness: 12 ft (3.6 m)

Interpretation: A minimum of 40 feet (12.2 m) of sand and gravel becoming denser with depth.

Line Number: MY-GT-4

Line Direction: N 75° E

Method: Hammer Seismic

Location: Harrow Geographic Township, Lot 12, Conc. 4

Elevation: Approximately 750 feet (229 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1150 ft/sec (350 m/sec)
V_2= 59,000 ft/sec (18,000 m/sec)
Layer Thickness: 11 ft (3.4 m)

Interpretation: Approximately 11 feet (3.4 m) of dry sand over bedrock.

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, MASSEY AREA

Line Number: MY-GT-5

Line Direction: N 10° W

Method: Hammer Seismic

Location: May Geographic Township, Lot 11, Conc. 5

Elevation: Approximately 800 feet (244 m) a.s.l.

Seismic Data:
Number of Layers: 2
Layer Velocities: V_1= 1300 ft/sec (400 m/sec)
V_2= 2650 ft/sec (810 m/sec)
Layer Thickness: 8 ft (2.4 m)

Interpretation: Approximately 8 feet (2.4 m) of loose sand and gravel over denser sand and gravel to a minimum depth of 33 feet (10.1 m).

GOUGH TOWNSHIP

Line Number: MY-GT-6

Line Direction: S 20° W

Method: Hammer Seismic

Location: Gough Township, Lot 4 Conc. 1

Elevation: Approximately 900 feet (274 m) a.s.l.

Seismic Data:
Number of Layers: 3
Layer Velocities: V_1 = 1310 ft/sec (400 m/sec)
V_2 = 2200 ft/sec (670 m/sec)
V_3 = 3600 ft/sec (1100 m/sec)
Layer Thickness: D_1 = 4 ft (1.2 m)
D_2 = 10 ft (3.1 m)

Interpretation: Approximately 14 feet (4.3 m) of sand and gravel over denser sand and gravel or till to a minimum depth of 40 feet (12.2 m)

TABLE 5 - SUMMARY OF GEOPHYSICS DATA, MASSEY AREA

SHAKESPEARE TOWNSHIP

Line Number: MY-GT-7

Line Direction: N 70° W

Method: Hammer Seismic

Location: Shakespeare Township, Lot 6, Conc. 3

Elevation: 950 feet (290 m) a.s.l.

Seismic Data:

Number of Layers: 2
Layer Velocities: V_1= 1330 ft/sec (405 m/sec)
V_2= 2130 ft/sec (650 m/sec)
Layer Thickness: 2 ft (0.6 m)

Interpretation: Approximately 2 feet (0.6 m) of gravelly sand over sand and gravel to a minimum of 33 feet (10.1 m).

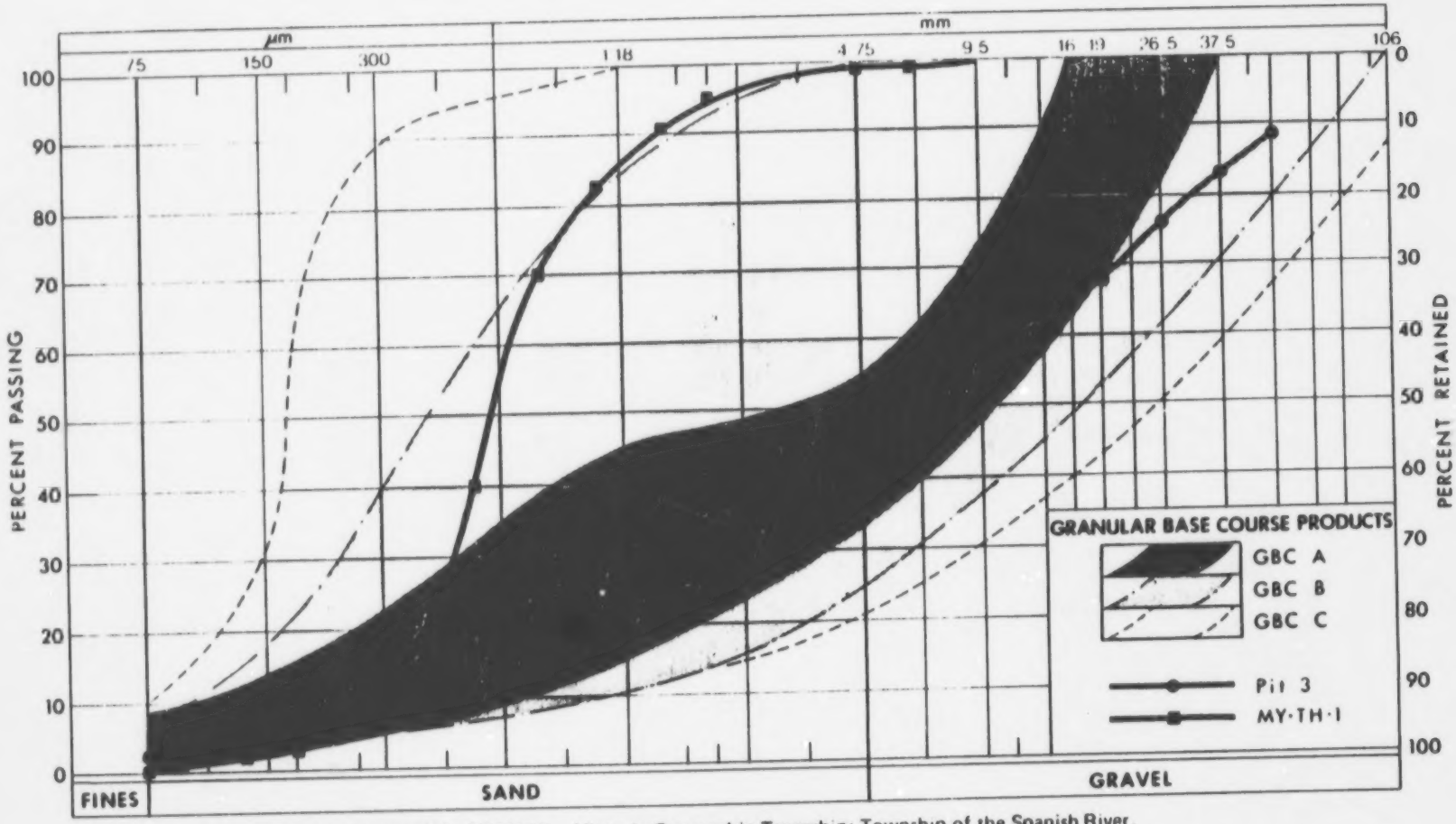

FIGURE 2a: AGGREGATE GRADING CURVES, Victoria Geographic Township; Township of the Spanish River.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

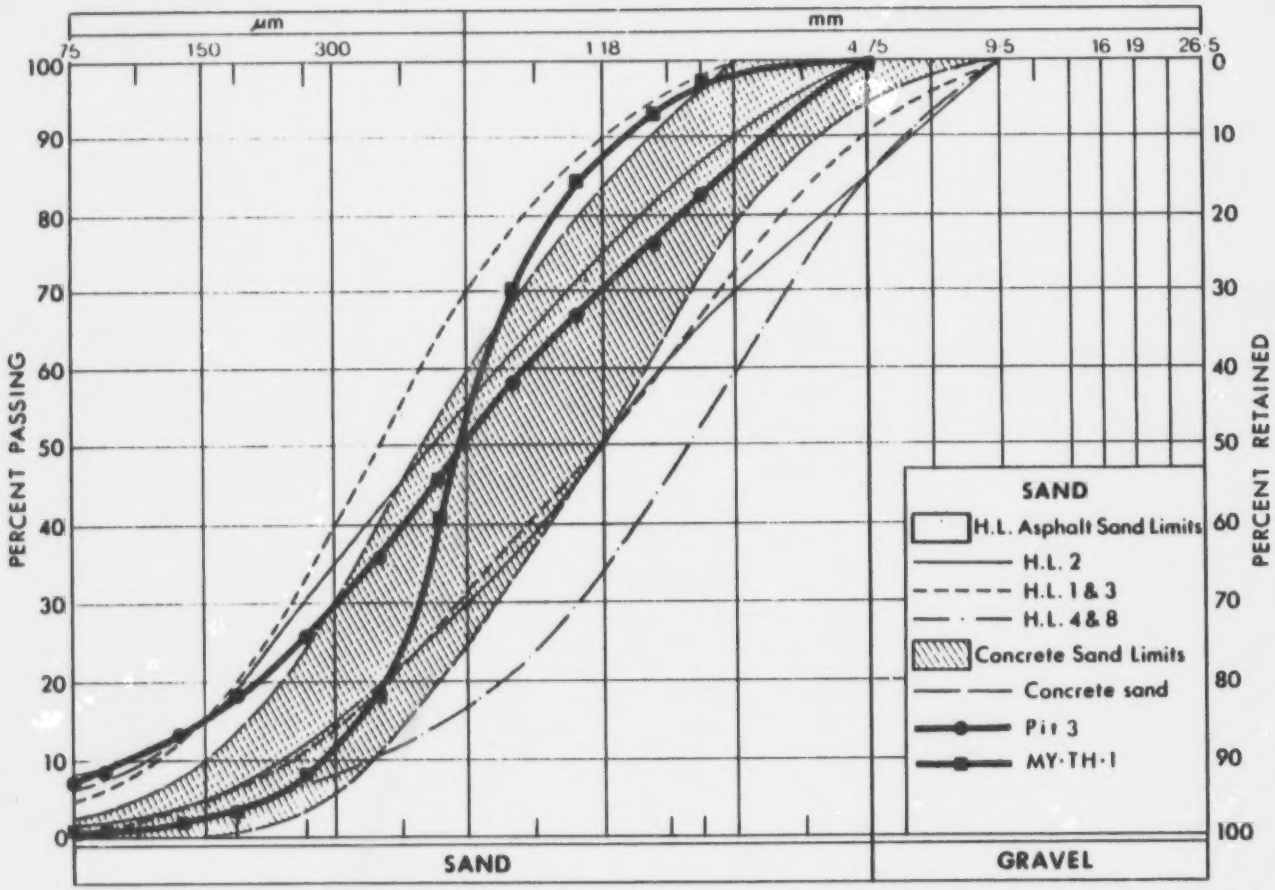

FIGURE 2b: AGGREGATE GRADING CURVES, Victoria Geographic Township; Township of the Spanish River.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

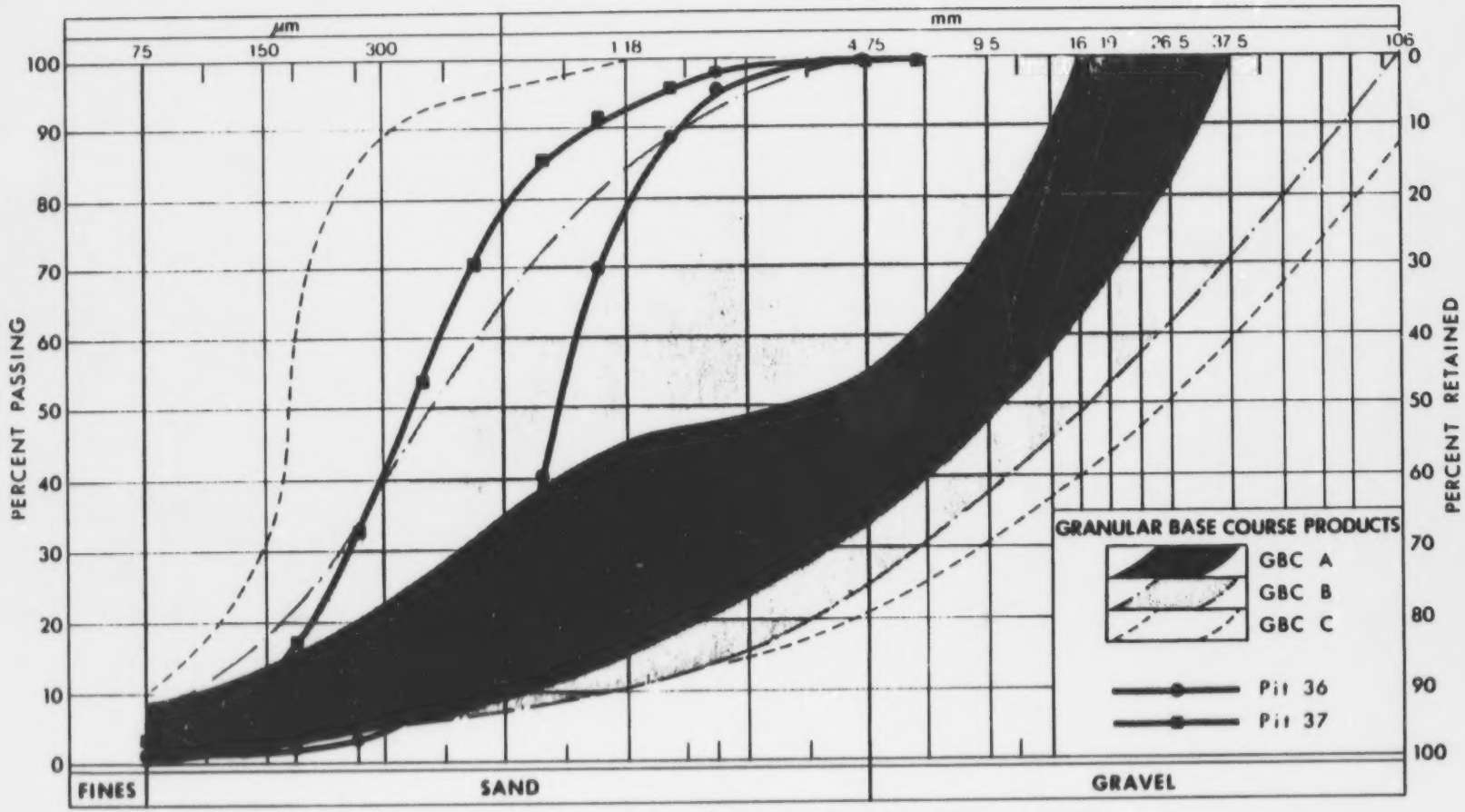

FIGURE 3a: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

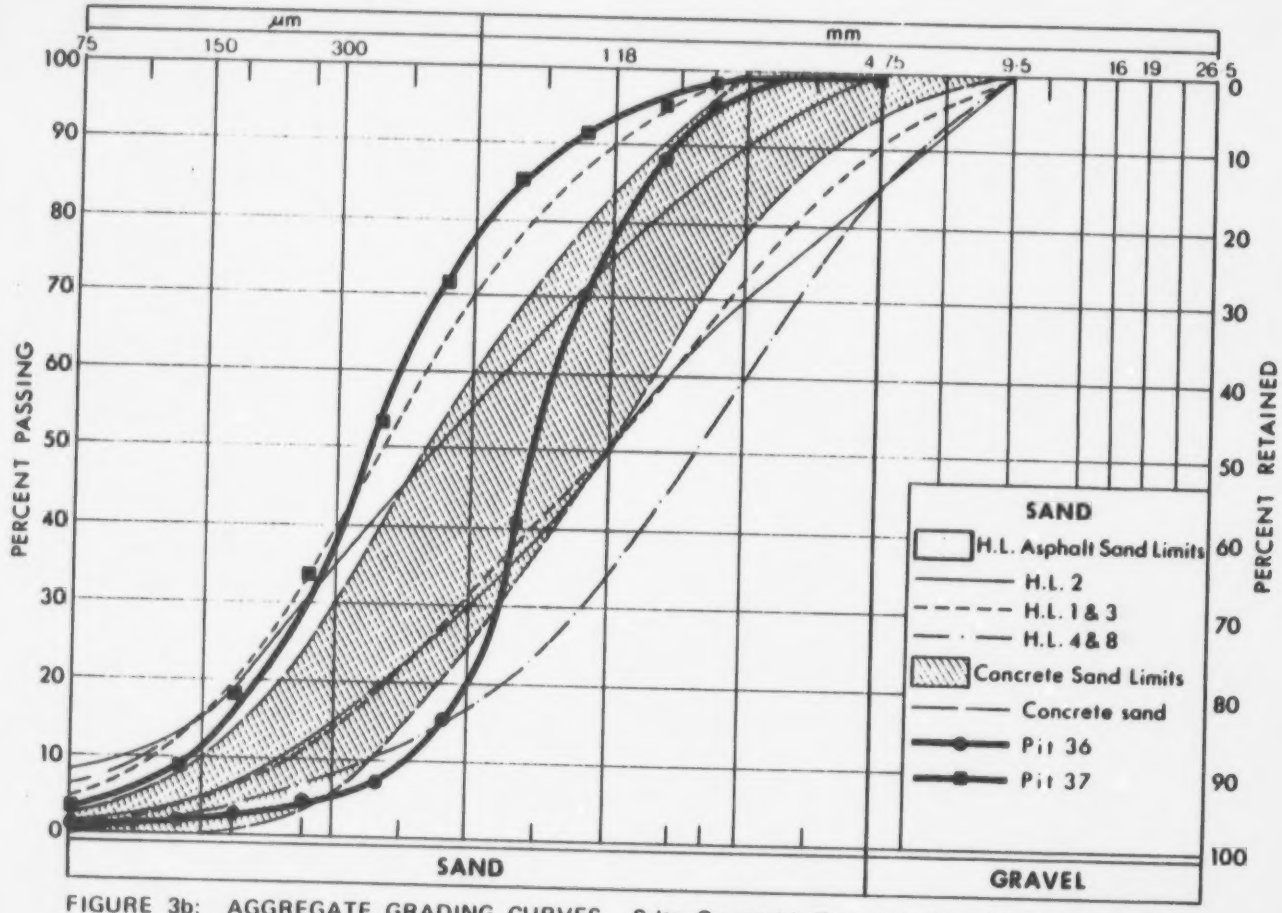

FIGURE 3b: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

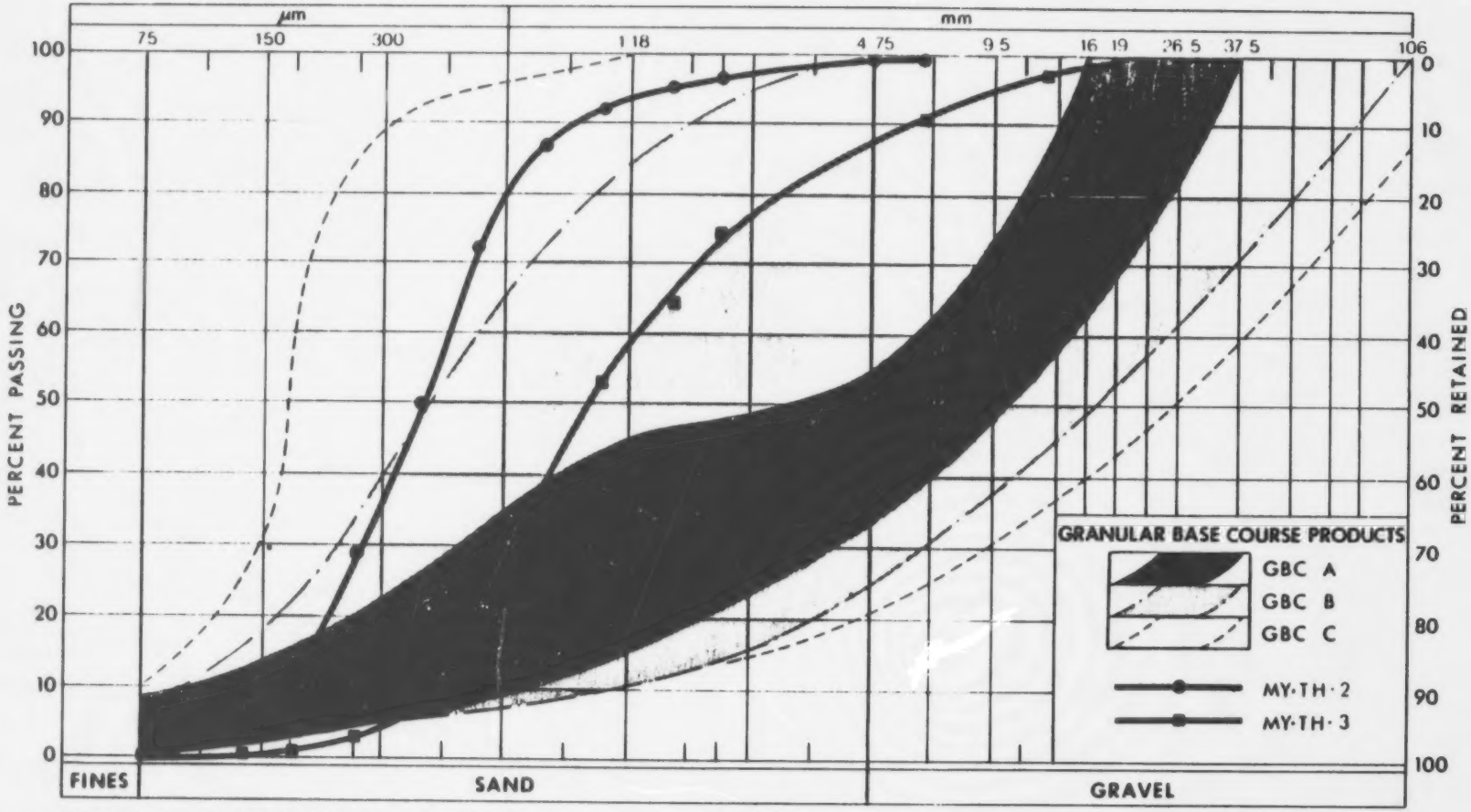

FIGURE 4a: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

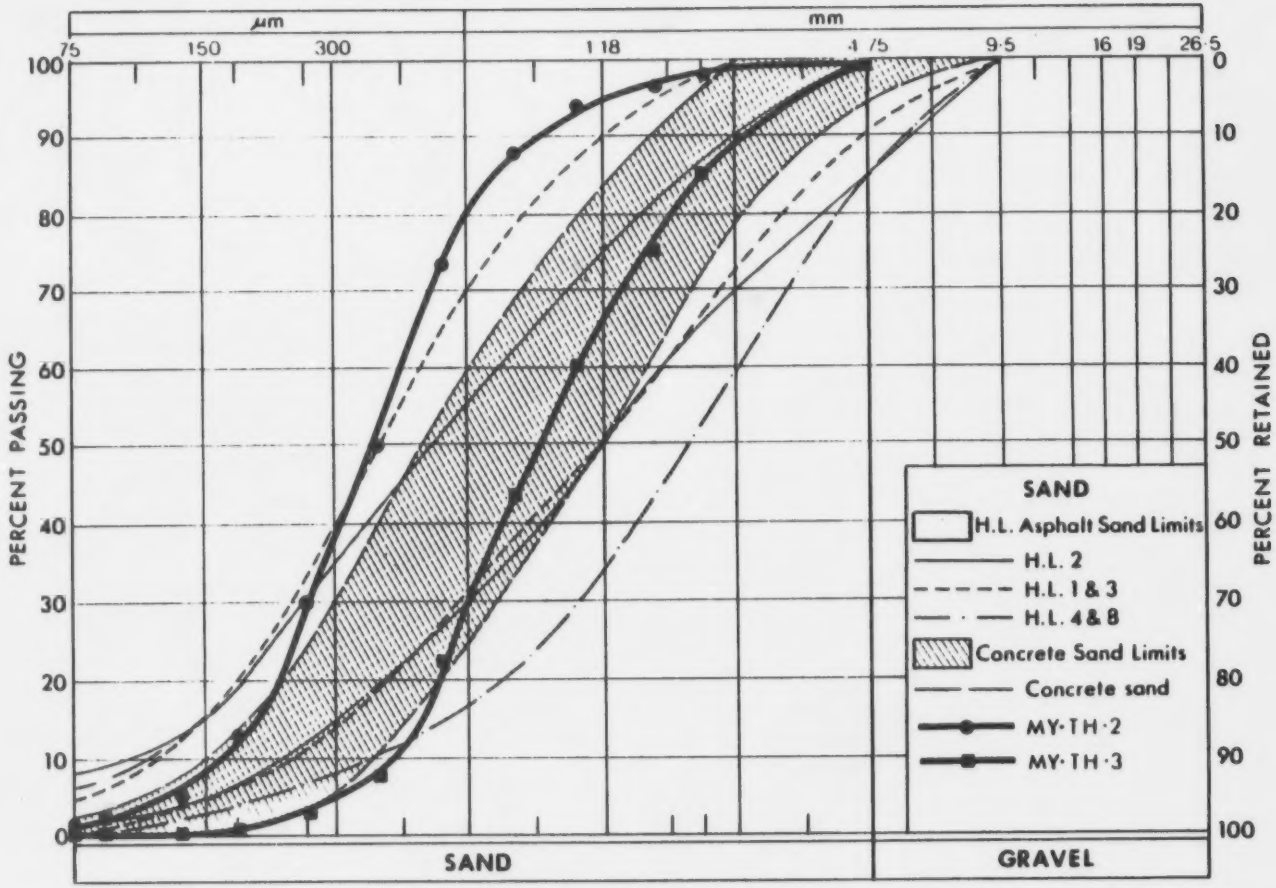

FIGURE 4b: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

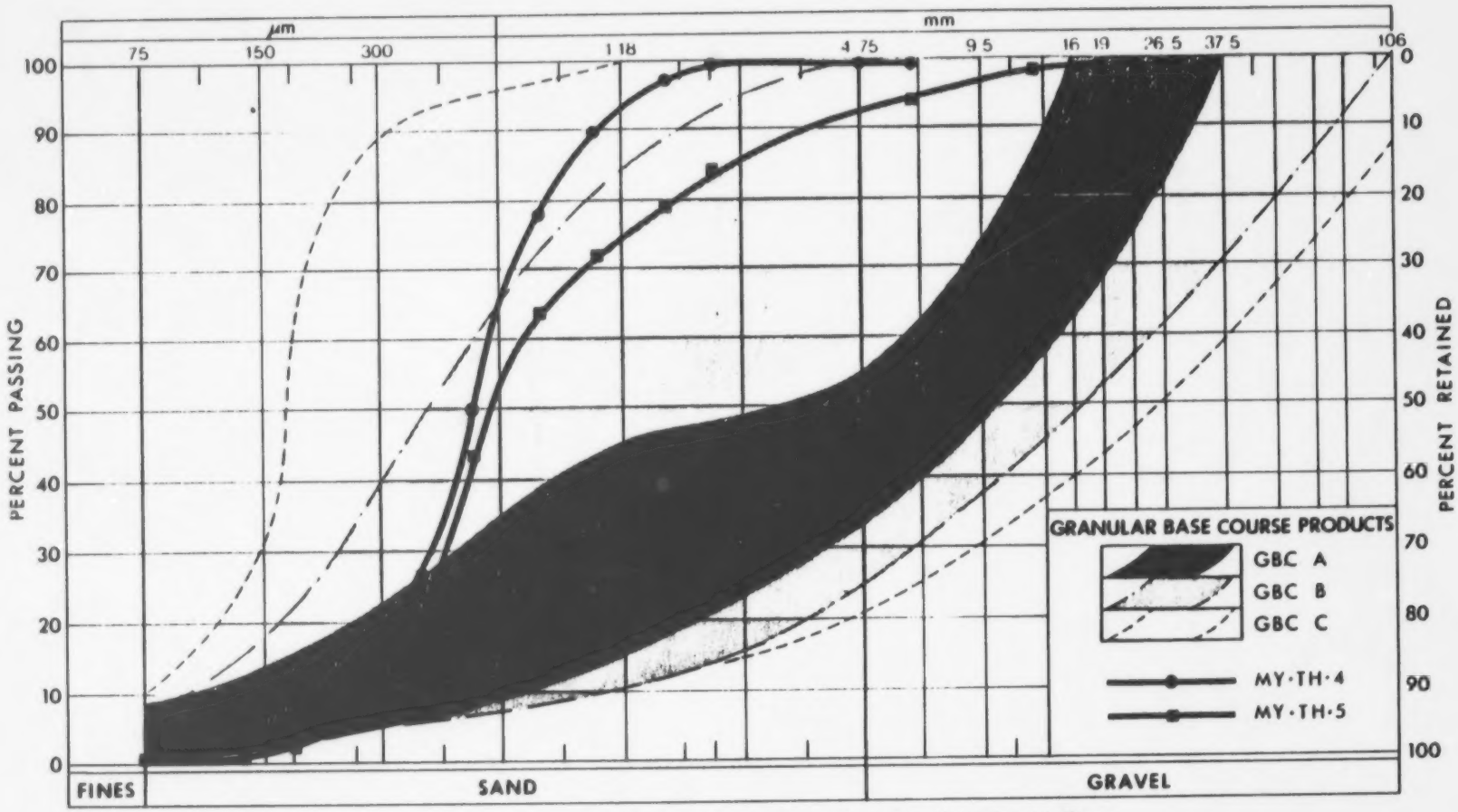

FIGURE 5a: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

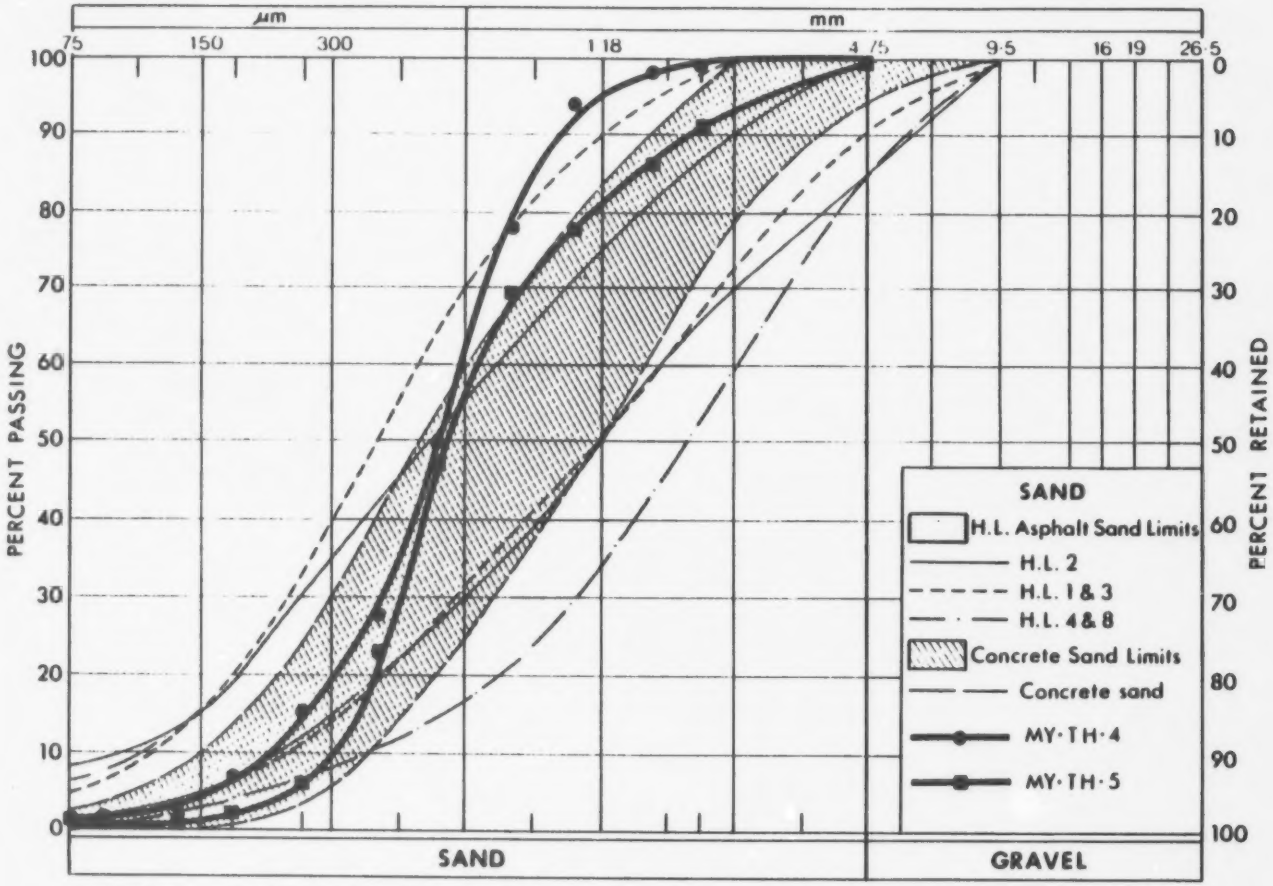

FIGURE 5b: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

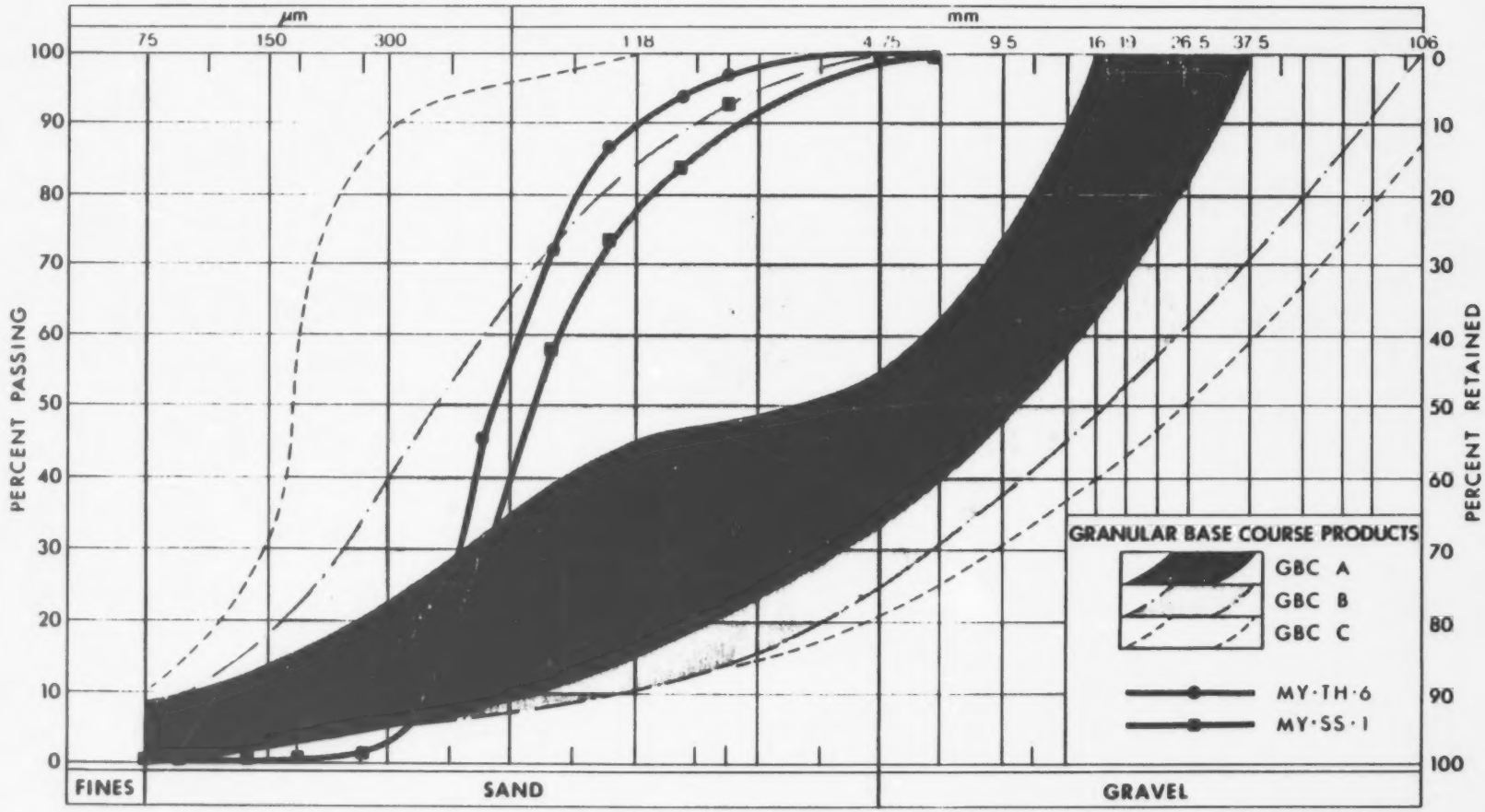

FIGURE 6a: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

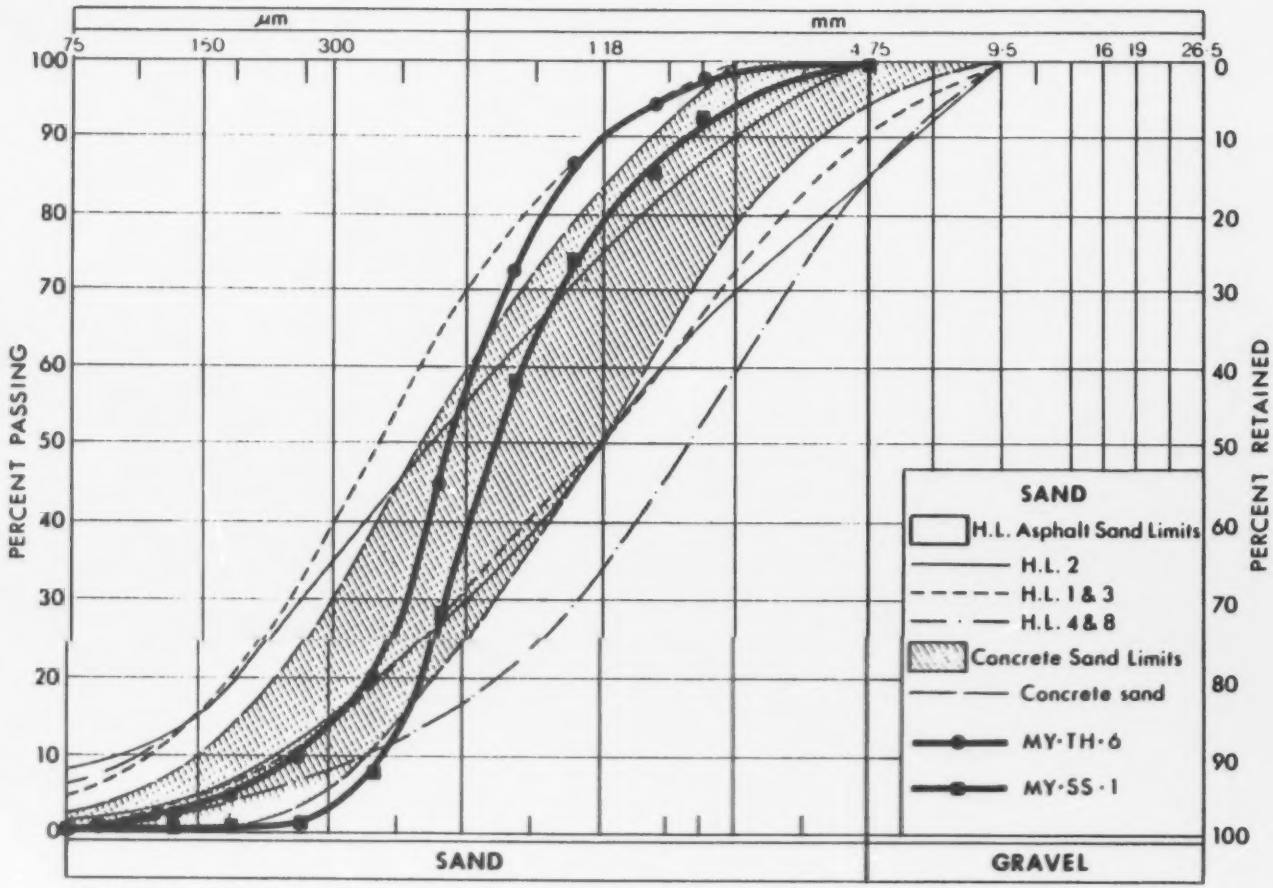

FIGURE 6b: AGGREGATE GRADING CURVES, Salter Geographic Township; Township of the Spanish River.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

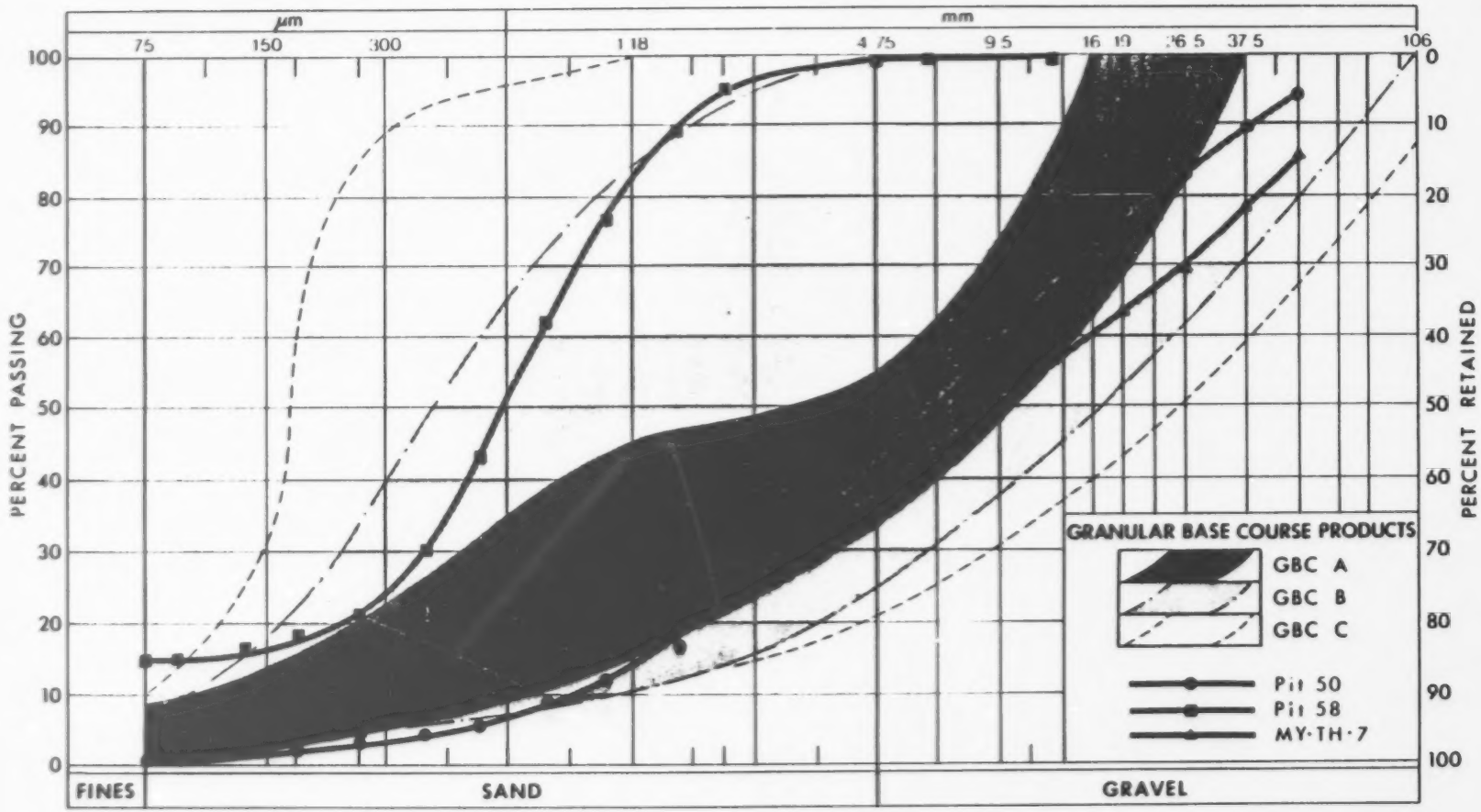

FIGURE 7a: AGGREGATE GRADING CURVES, Harrow Geographic Township; Township of the Spanish River.

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

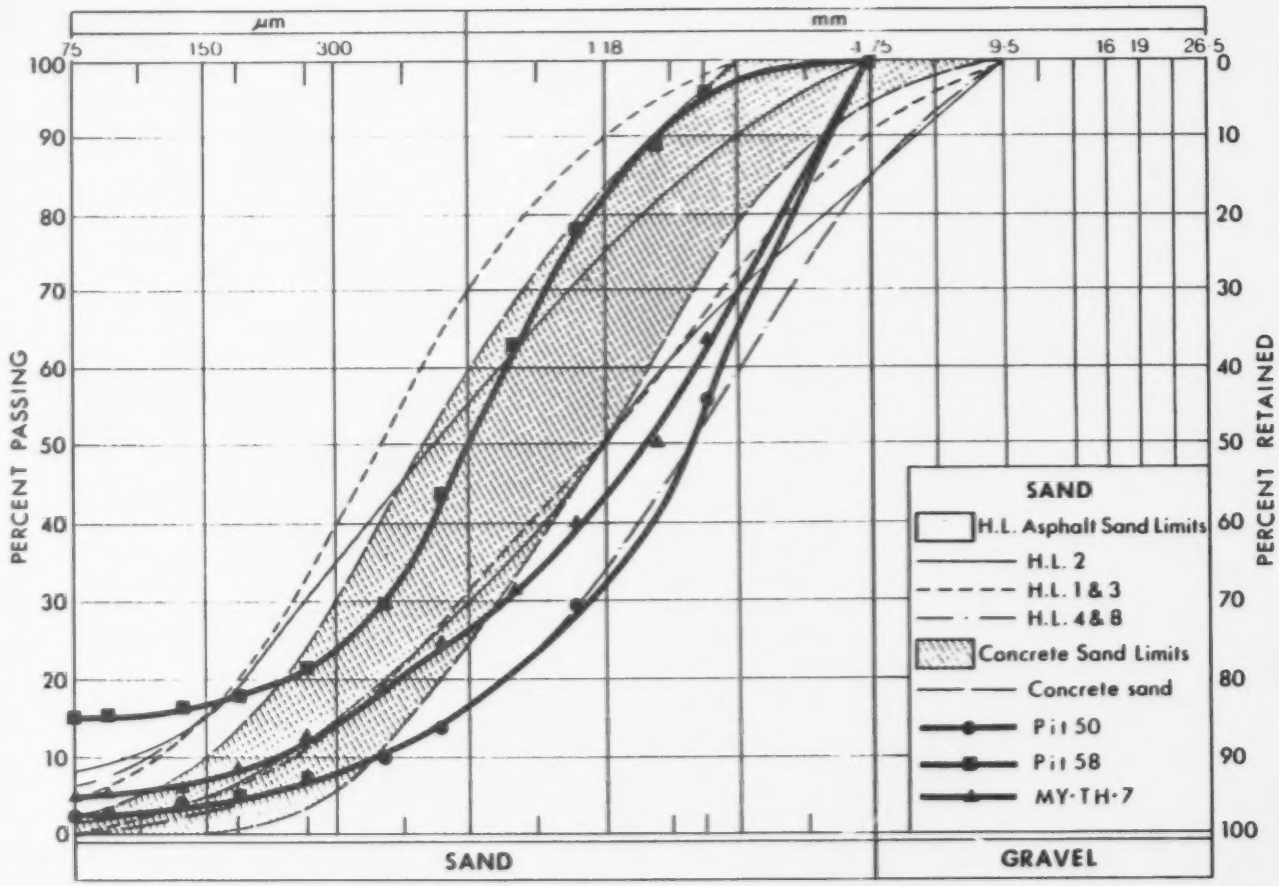

FIGURE 7b: AGGREGATE GRADING CURVES, Harrow Geographic Township; Township of the Spanish River.

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

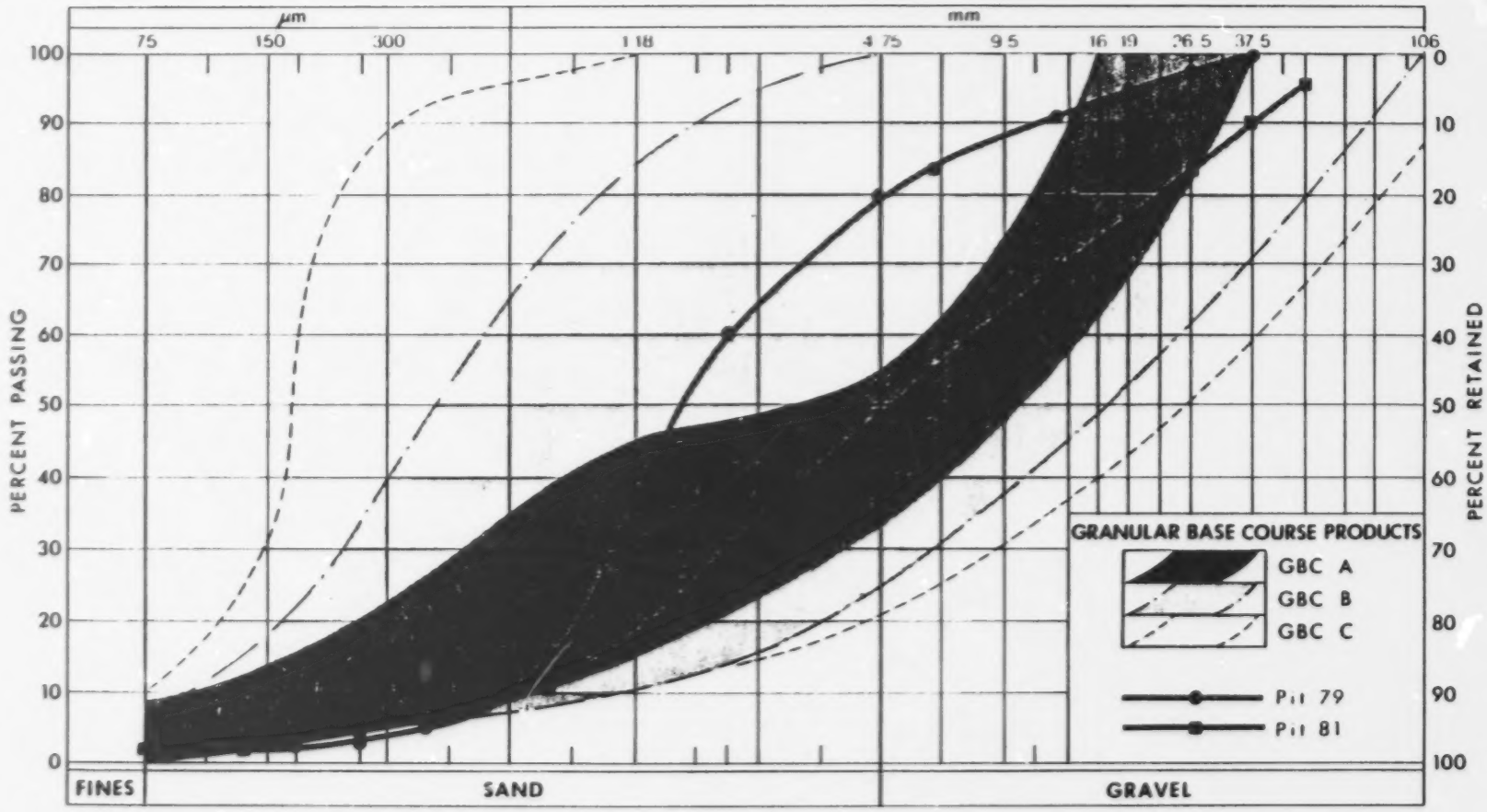

FIGURE 8a: AGGREGATE GRADING CURVES, Gough Township;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

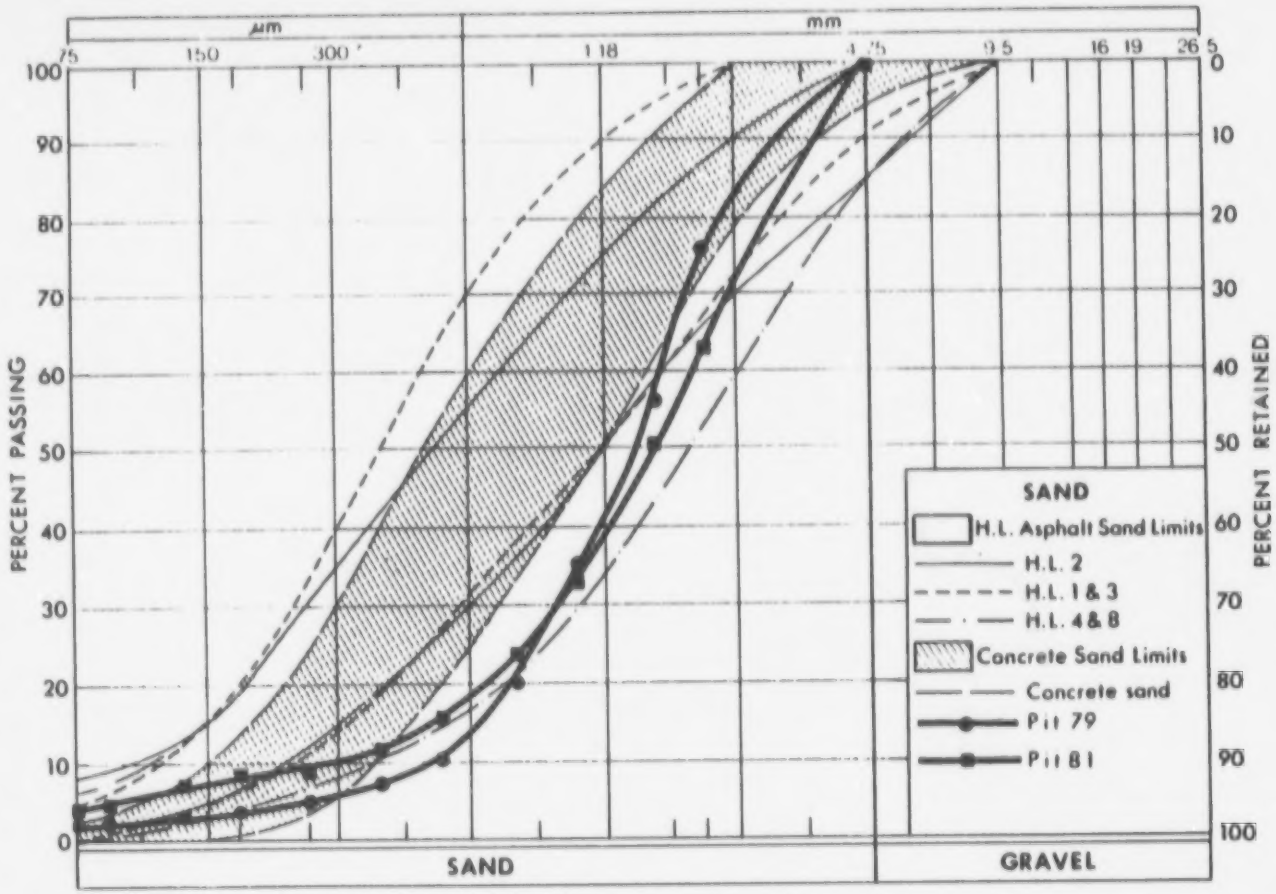

FIGURE 8b: AGGREGATE GRADING CURVES, Gough Township;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

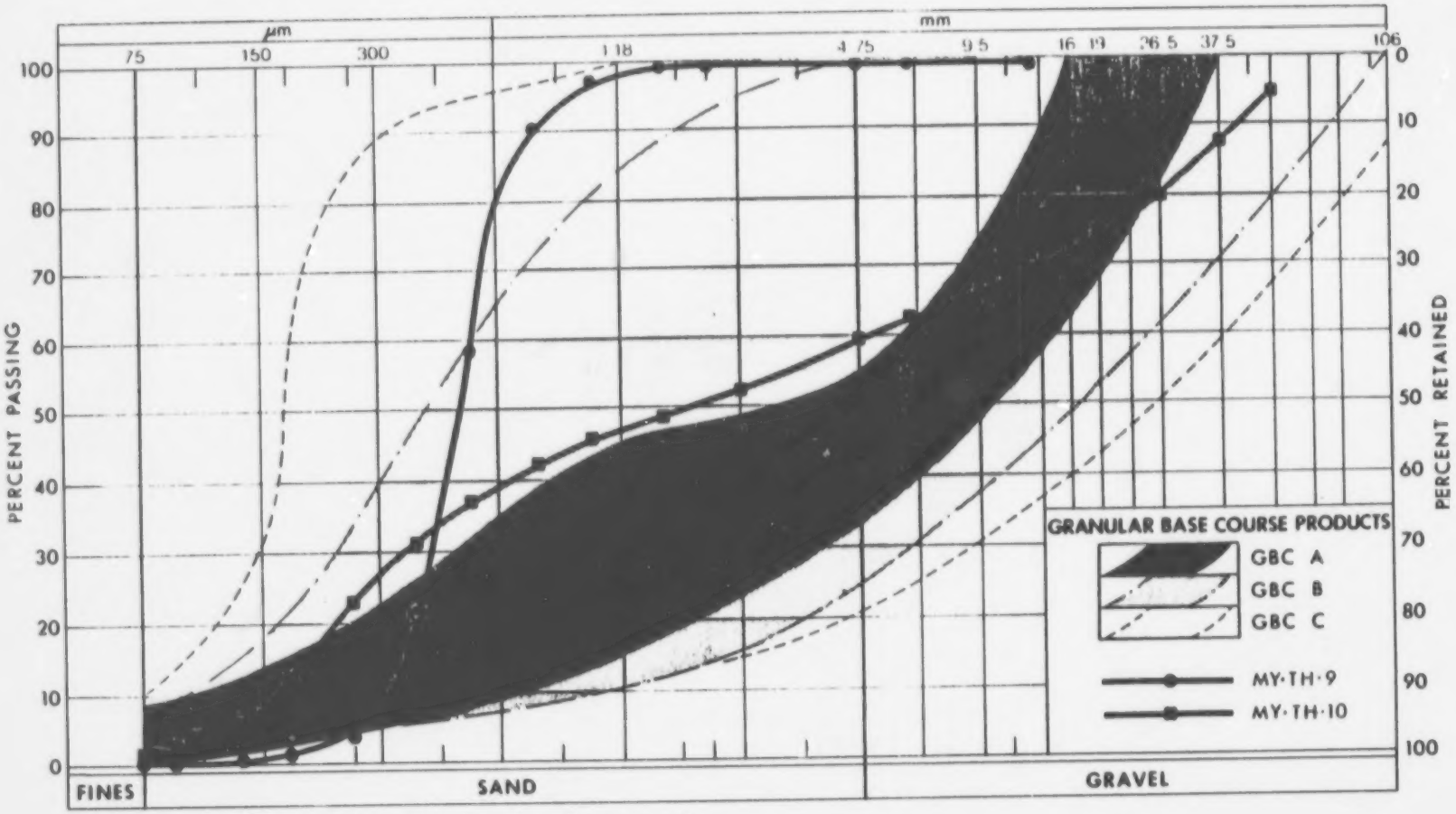

FIGURE 9a: AGGREGATE GRADING CURVES, Gough Township;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

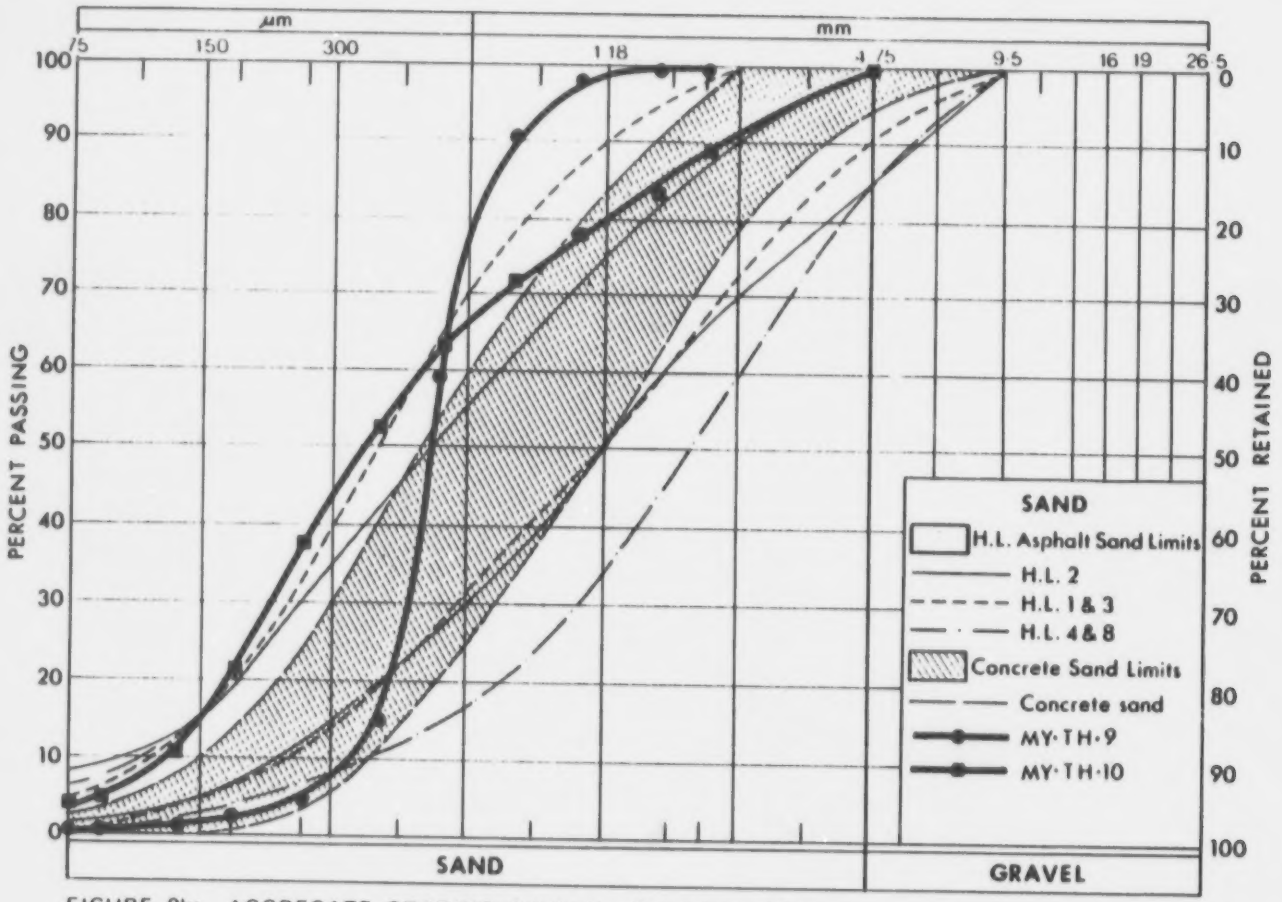

FIGURE 9b: AGGREGATE GRADING CURVES, Gough Township;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit

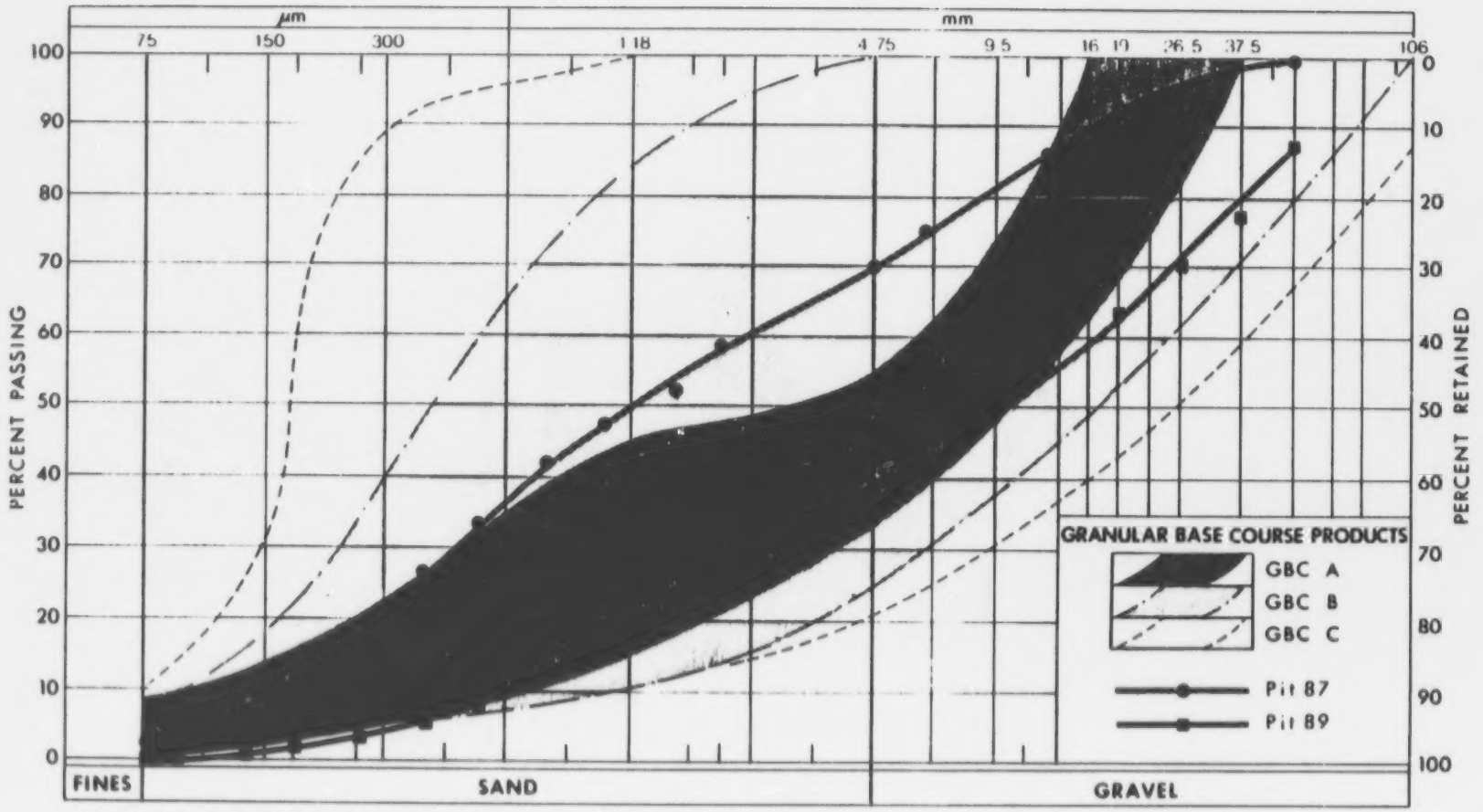

FIGURE 10a: AGGREGATE GRADING CURVES, Shakespeare Township;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

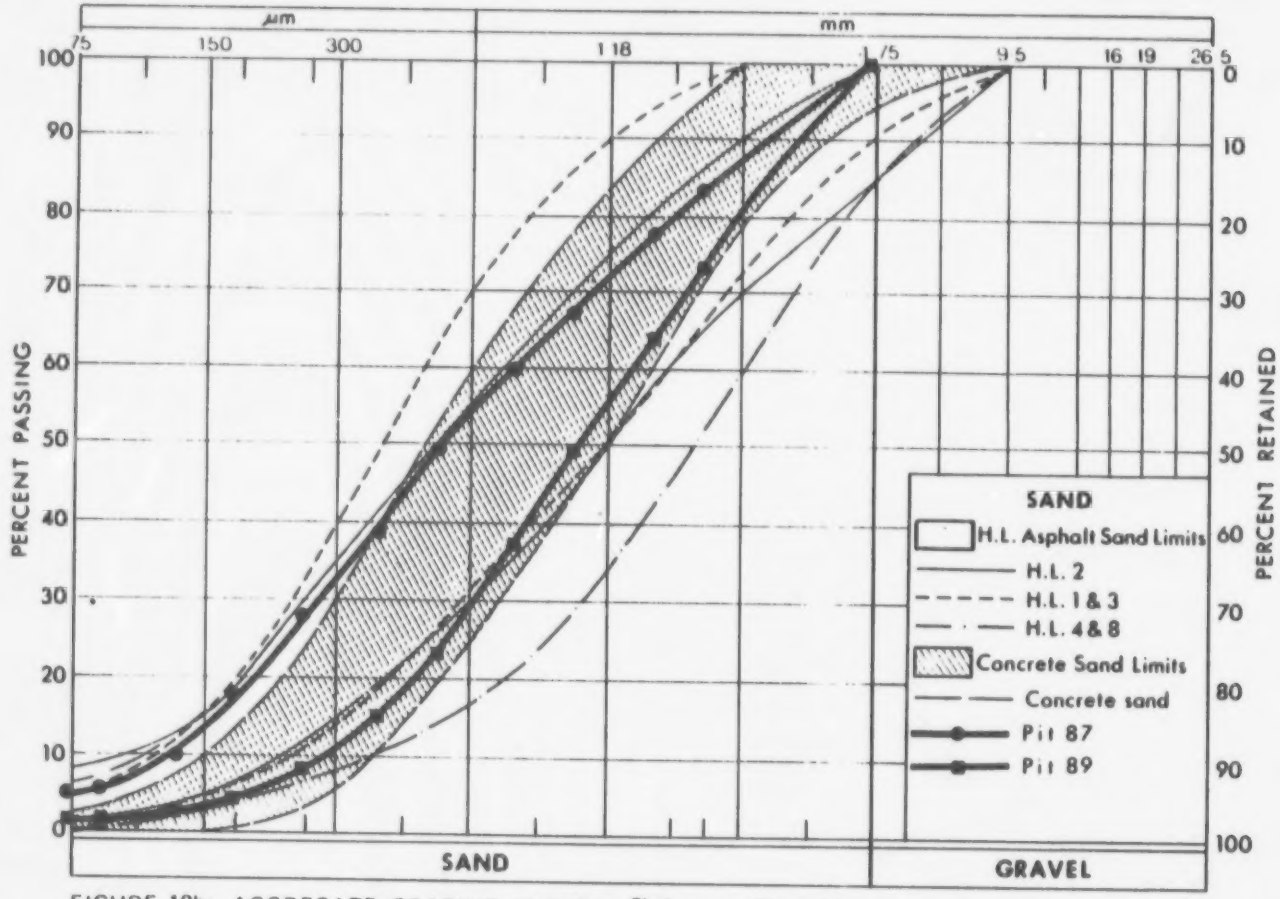

FIGURE 10b: AGGREGATE GRADING CURVES, Shakespeare Township;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX A - PURPOSE, METHODOLOGY AND DATA PRESENTATION OF THE AGGREGATE RESOURCES INVENTORY*

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1984, the total tonnage of mineral aggregate extracted was 109 million tons (99 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Weatherson 1986).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where the deposits occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of the deposit is a function of its proximity to a market area, as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons, the availability of adequate resources for future development is now being threatened in some areas.

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* This Appendix is made up of the standard Introduction and Part I and II from the Aggregate Resources Inventory Paper (A.R.I.P.) series (for example, see A.R.I.P. 89, Aggregate Resources Inventory of the Central Part of the City of Timmins). The text has been modified slightly to correspond to the data presented in this Open File Report. The methodology and data presentation used in this OFR are identical to those used in the A.R.I.P. Series.

Comprehensive planning and resource management strategies are required to make best use of available resources. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of all the sand and gravel resources in the study area. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References), as well as field examination of potential resource areas. Field methods included the examination of natural and man-made exposures of granular material. Observations were made at sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications (M.T.C.), the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. Airphotos were used to determine the continuity of deposits, especially in areas of limited information.

Deposits with potential for further extractive development or those where existing data were scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 45-kg)

units from existing pit faces. The samples were analyzed for grain size distribution. In areas of limited subsurface exposure, test holes were excavated using a wheeled backhoe. Location of test holes are shown on Map 1 and test hole data are summarized in Table 4. As well, geophysical surveys were undertaken using a portable hammer seismic unit. The location of geophysical traverse lines are shown on Map 1 and the geophysical data are summarized in Table 5.

The field data were supplemented by pit information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional aggregate sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were referred to at the preliminary assessment stage to identify areas of possible buried granular material. These records were used in conjunction with other evidence. Topographic maps of the National Topographic

System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The base map was prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

Sand and Gravel Resources

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factory (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent for the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel are termed possible resources (see Glossary, Appendix B) in accordance with terminology of the Ontario Resources Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976).

PART II - DATA PRESENTATION AND INTERPRETATION

There are two maps, each portraying a different aspect of the aggregate resources in the report area. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

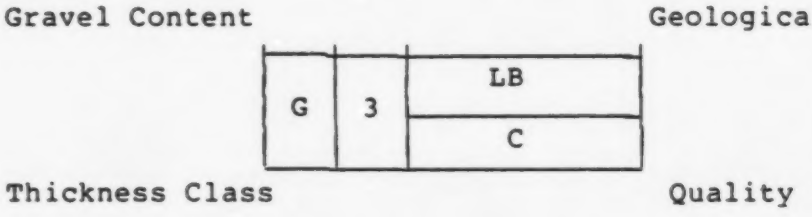
Map 1 is derived directly from existing surficial geology maps of the area or from aerial photograph interpretation in areas where mapping is incomplete. The map represents a comprehensive inventory of sand and gravel deposits within the project area and serves as a base for the calculation of total sand and gravel resources.

On the map, all sand and gravel deposits are outlined and shaded. The present level of extractive activity in the area is also indicated. All known sand and gravel pits, whether presently active or inactive, are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location of the pit and the estimated face height and gravel content. In addition, test hole locations appear on Map 1 as a point symbol, and test hole logs appear in Table 4. Geophysics lines are shown on the Map by a line symbol and are interpreted in Table 5.

The map also represents a summary of all available information related to the quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

Deposit Symbol

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies a lacustrine beach deposit 5 to 10 feet (1.5 to 3 m) thick containing more than 35 percent unprocessed gravel. Excess fines may limit uses of the

aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. The "G" indicates that the deposit probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix D) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

Texture Symbol

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and fines in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional

segments.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary and tertiary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is given a deposit number and all such deposits are shown by a dark tone on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such resource areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are indicated by a light tone on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas, they may contain large quantities of sand and gravel and should be considered as part of the

aggregate supply of the municipality.

Areas of tertiary significance are outlined on the map by a solid line, but have no tone. They are neither rated nor considered to be important resource areas, because of their low available resources or because of possible difficulties in extraction. Such areas may be useful for local needs, but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be

of significant value depending on the overall reserves in the rest of the project area. Generally, deposits in Class 1, (greater than 20 feet (6 m) thick) and containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve are considered to be most favourable for commercial development. Thinner deposits may be valuable in areas with low total resources.

Aggregate Quality

The limitations of natural aggregate for various uses result from variations in the lithology of the particles making up the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols. They are: Gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the quality indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve, and also a minimum of 20 percent larger than the 1 inch (25 mm) sieve, are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the

effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent "oversize" material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete and road-building aggregate, so must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit symbol indicates either "C", "O", "L" or any combination of these indicators, the quality of the

deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications (M.T.C.) and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes or pits are plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course (G.B.C.) A, B, and C; and Hot-Laid (H.L.) Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the grading curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product. These graphs, called aggregate grading curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high

water table, are less valuable resource areas, because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at

the same level.

The aggregate resources in the region surrounding a project area should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, an area that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Areas with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

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APPENDIX C - GLOSSARY

ABRASION RESISTANCE: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CLAST: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DOLOSTONE: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing a complex arrangement of glacial material and landforms.

GNEISS: A coarse textured metamorphic rock with the minerals arranged in parallel streaks or bands, but lacking schistosity. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANULAR BASE COURSE: Components of the pavement stucture of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALITC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE: Reserve estimate based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geologic period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX D - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsin time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable.

Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

ESKERS (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and

thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario, such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAINS (LP): These are the nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of

low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

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